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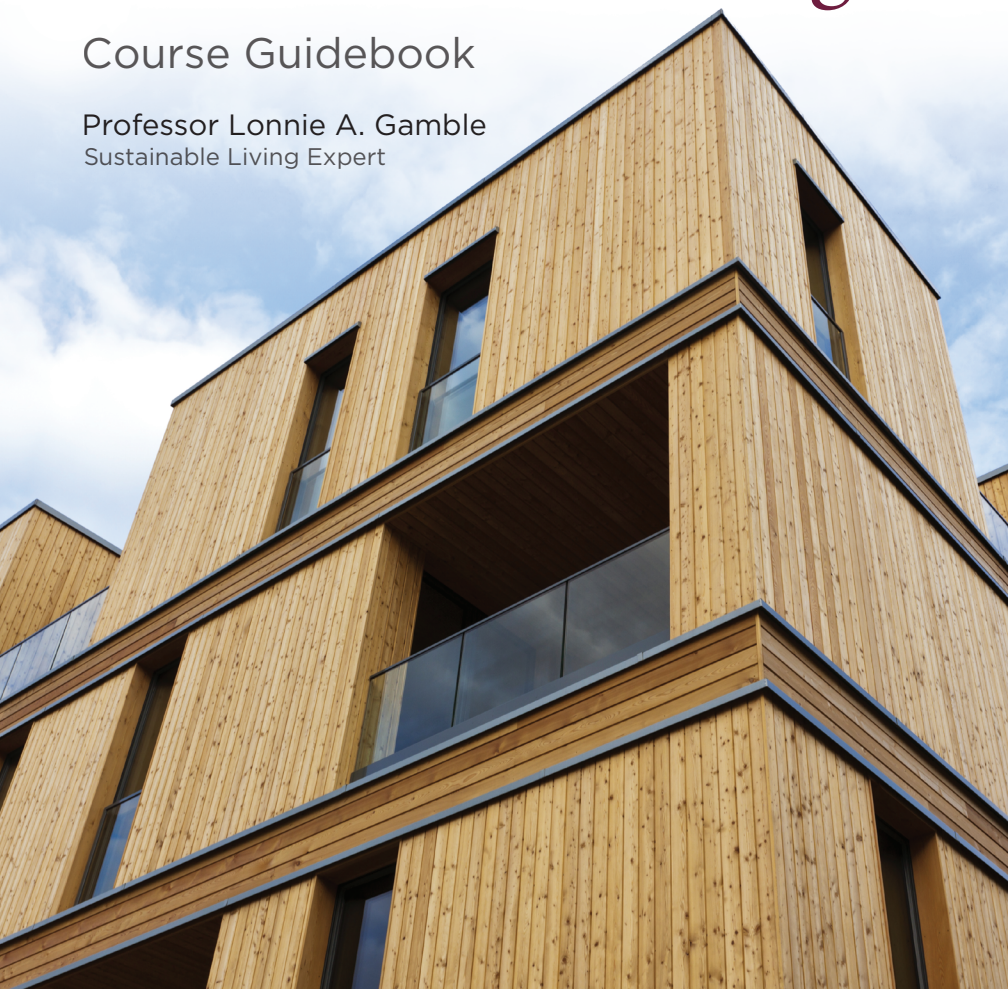
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Better Living

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Fundamentals of Sustainable Living

Course Guidebook

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Sustainable Living Expert



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Professor Lonnie A. Gamble is a founding faculty member and codirector of the Sustainable Living program at Maharishi University of Management in Fairfield, Iowa, where he has taught since 2003. Professor Gamble has a Bachelor of Science degree in Electrical Engineering from North Carolina State University. He has done additional studies in renewable energy, cognitive science, and computer science at the University of Maine, Maharishi University of Management, and the University of California, San Diego.

Professor Gamble is a cofounder and former board chair of the Sustainable Living Coalition. He is on the board of the Center on Sustainable Communities and on the advisory board for the Entrepreneurial & Diversified Agriculture program at Marshalltown Community College. He was appointed by the mayor of Fairfield to the city's Sustainability Committee and Go-Green Planning Commission.

Professor Gamble has founded half a dozen companies in the areas of renewable energy, telecommunications, sustainable building and development, and sustainable agriculture. His interests include renewable energy, high-performance building, natural building, sustainable economics, sustainable agriculture, and the relationship between consciousness and sustainability. He is one of the founders of the emerging field of deep sustainability. Professor Gamble writes, speaks, teaches, and develops curricula regularly in his areas of interest. He has worked on international development projects and consulting assignments and has lectured in Bhutan, Mongolia, Hawaii, and Taiwan. He also has a consulting practice in the design of high-performance buildings and renewable energy systems.

Professor Gamble has received numerous teaching and service awards, including the teacher-of-the-year award at Maharishi University of Management, an award from the Iowa Chapter of Sierra Club, an award from the mayor of Fairfield for his sustainability work in the city, the Entrepreneur of the Year award from the Fairfield Entrepreneurs Association, and a fellowship and an award from the Agrestal Fund. He has received \$250,000 in grants from a wide range of foundations in support of his work.

Professor Gamble has published papers in the proceedings of the American Solar Energy Society and in a number of popular periodicals, including *Home Power* magazine and *The Iowa Source*. He has presented papers at a wide range of academic conferences, including the American Solar Energy Society, the Communal Studies Association, the Iowa Renewable Energy Expo, and the Degrowth in the Americas conference in Montreal. Professor Gamble is the founder of the Abundant Planet Radio collective and has appeared on public radio in several states. He is a cofounder of the New Academy for Sustainability and organized the national Transcending Sustainability conference.

Professor Gamble lives with his wife and son in a straw-bale, solar-powered house; eats something fresh from his garden every day; and hasn't paid an electric bill for 23 years. ■

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Disclaimer

This series of lectures is intended to increase your understanding of the principles of Fundamentals of Sustainable Living. These lectures include experiments in the field of Transportation Alternatives and the Ecocity, performed by an experienced professional. These experiments may include dangerous materials and are conducted for informational purposes only, to enhance understanding of the material.

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Fundamentals of Sustainable Living

Scope:

We humans have a plethora of environmental, social, and ecological problems, and the dominant ways of living in our world are not sustainable. It can be argued that these problems are baked into the design of our institutions and economic systems. In this course, the problems of the world are left for others to analyze in depth. You will learn about the worldview that modernity is based on and that our current institutions flow from, and then you will explore what a sustainable worldview looks like, as well as the institutions and ways of living that might flow from it. You will balance learning the theory of a sustainable world with practical details and examples of living sustainably now.

The sustainability revolution changes everything. Every aspect of human endeavor will be affected by sustainability, so sustainability is inherently an interdisciplinary endeavor. You will be introduced to a sample of the leading thinkers and ideas of the sustainability movement, including William McDonough and his ideas for going beyond recycling to upcycling and Bill Mollison and permaculture design. You will learn practical details of how you can provision your life with food, water, energy, and shelter in a sustainable way.

You will be exposed to some leading examples of sustainable design. You will learn how to make really great compost and build a 100-dollar greenhouse that can be used to grow food throughout the winter anywhere in the United States. You also will learn about the design and use of simple drip irrigation and rainwater-collection systems.

In addition, you will learn how your consumer and investment choices can drive sustainability and what the limits are of how our individual choices affect sustainability.

Energy and the law of entropy play a fundamental and somewhat mysterious role in the development of order and structure in the universe and, therefore,

in sustainability. You will be introduced to examples of this in such diverse fields as agriculture and sustainable economics.

Sustainability involves thinking in systems—how seemingly disparate things like energy, water, agriculture, and buildings are all related. Design is the first signal of human intention, and you will learn how a holistic design process grounded in systems thinking is fundamental to sustainability. Sustainability can be thought of as the intellectual exploration and practical application of the interconnectedness of human and natural systems. This external interconnectedness is complemented by the internal experience of interconnectedness to nature through meditation or experiences in nature, and you will explore inner sustainability, as well.

Sustainability involves becoming more efficient with how we use energy and material resources, replacing toxic materials and processes with nontoxic ones, such as exchanging toxic pesticides for nontoxic methods of insect management. You will explore why these necessary measures aren't sufficient for sustainability: Sustainability involves putting efficiency and substitution in service to a radical redesign for regeneration and renewal of the human, material, and energy resources on which we depend.

We are material beings, so sustainability has a material dimension. But we are also social and ethical/spiritual beings, and we will explore how all these aspects of sustainability relate.

Finally, you will examine sustainability in the context of other great revolutions in the way that humans relate to each other and to nature, such as the agricultural, scientific, industrial, and information revolutions. Sustainability will inform everything that humans do. Thomas Berry argues that the sustainability revolution is bigger than anything that humans have ever done before and calls it the “great work” of the upcoming generations. We're just in the beginning stages of this revolution, and this course will help you understand it as it unfolds.

In this course, you will discover how the disparate parts of sustainability can come together into a holistic design for sustainable living. You will learn what you can do now to be a pioneer in the sustainability revolution. ■

Making Your Lifestyle Footprint Regenerative

Lecture 1

The goal of this course is to teach you how you can begin to favor the principles of sustainability in your life, to become a participant in the sustainability revolution—in as big or as small of a way as you can. In this course, you will explore such sustainable topics as growing food at home, using solar energy, harvesting rainwater, and even rethinking investments. Rather than being passive consumers, we can become coproducers of food, energy, building materials, and more.

Living Sustainably

- When thinking about sustainability in your life, you need to consider everything. In other words, every dimension of your life can be reconsidered in terms of sustainability. This includes material dimensions of life, such as energy, food, water, housing, transportation, and city/rural context. But we aren't just material beings. We are social beings, needing to love and be loved, and we are spiritual beings, needing a sense of purpose and meaning.
- There are two nonmaterial aspects to sustainability: one that deals with social institutions (such as education, governance, and economics, as well as work, relationships, and a sense of purpose and meaning) and another that has to do with understanding our purpose in life. If there's no purpose, or the purpose isn't good, sustainability makes no logical sense.
- Today, sustainable ways exist side by side with unsustainable ways. For example, there has been a convergence toward sustainable building over the past few years. Today, it's pretty difficult to find an architecture program that isn't rooted in the principles of sustainable design. Buildings use 50 percent of the energy that flows through the economy, and the American Institute of Architects has a plan to bring that to zero.

- Design is the first signal of human intention. If we get the initial design right, then we often get cascading side benefits. If we get the initial design wrong, then we are left to deal with cascading side effects. In the future, there won't be separate sustainable options; it'll just be the way we live and do business.
- In the past 50 years, the supply chains that provide us with our material needs have become global in scope. We've gone from getting our food, shelter, and energy from within our local communities to sourcing our needs from a global marketplace.
- This made sense when energy was cheap and global warming wasn't a concern. But we have a whole new set of technologies that provide us with local solutions, such as harvesting solar energy from our rooftops, and new approaches to urban agriculture and organic agriculture that allow us to grow food in and around urban areas.
- Part of sustainability is going back to getting energy, food, and building materials sourced locally and sustainably. There are many



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Installing solar panels on your roof is just one way to make your home more sustainable.

ways to relocalize in your home and community, such as growing food in your backyard or on your porch, developing relationships with local farmers, planting fruit trees in public parks, generating your electricity from solar energy, harvesting rainwater, and building a home from local and natural materials.

- If we get more of our needs met locally, the good and bad consequences of how we provision our lives become visible, and we become directly aware of the consequences of our actions. We create interest and economic activity in our communities.
- The places formerly used to get the stuff we need can be restored to wetlands, wildlands, and beauty, providing essential services for all life on Earth. Cultivating them as wetlands and wildlands as well as protecting their beauty becomes our role—not exploiting them to satisfy unsustainable needs and wants.

The Design of Sustainability

- Sustainability means that we need to consider the impact of our current use of natural resources, materials, and energy on future generations. For example, we can make electricity from fossil fuels or from solar energy. Fossil fuels are a store of energy that we are using up, and what we use means less for future generations. Solar energy is a flow of energy that is replenished daily. Learning to use it now leaves future generations better able to meet their needs for energy.
- Sustainability involves dedicating significant resources to the regeneration and renewal of the human and natural systems that we—and our children, and their children—all depend on.
- Sustainability is really all about understanding energy. Everything of use to us requires energy. Houses, clothes, and cars require energy to make and energy to use. All material things are concentrated energy. Human usefulness—our thinking, our working, our creative minds—is all about energy. Even our social relationships with one another require and use up energy.

- We have to have biological energy to fuel the body, the mind, and the spirit. In addition, we need energy to make humans productive. We're born as helpless babies, and we need to be nurtured, cultured, and educated. All of this takes energy.
- The first law of thermodynamics says that energy is neither created nor destroyed, so you might think that we can just use it over and over again. But the second law of thermodynamics says that every time we use energy, some of its usefulness is lost. Whenever we use energy, it always changes in form, and it always changes in form in a particular direction: from a more concentrated, organized form to a more dissipated, disorganized form.
- No matter how efficient we get in recycling and conserving, we are inevitably moving toward entropy—we're depleting usefulness. We're using up the ability of the planet to support life. Once we deplete the usefulness of nature and society, there is no place to get more.
- It seems that we may have to do three things: slow down our use of resources, explore alternative sources of energy, and learn to create human systems that regenerate and renew. This includes the systems that work within the great ecology of nature, such as the hydrologic cycle; the systems that recycle materials; and the systems that maintain the fertility of the soil.
- The great news is that we have a big, beautiful source of energy that offsets the inevitable loss of usefulness to entropy: solar energy. We have solar energy to regenerate and renew and for sustainability. That's our alternative energy source.
- Unfortunately, many people think that slowing down our use of resources is all about cutting out, cutting back, and self-denial. But sustainability is not about doing without; it's about learning to work within the abundant flows of natural systems.
- Sustainability is about efficiency and substitution. We need to be more efficient at the way we're using energy and materials. We

need to replace toxic ways of doing things with nontoxic ways that work with nature rather than against it.

- But efficiency and substitution are not enough. We need to create systems that, like nature, use solar energy to regenerate and renew the lost usefulness caused by entropy. Then, we can begin to create systems that work with and celebrate nature's abundance today, creating the possibility for future generations to do the same.

The Human Ecological Footprint

- Much current discussion about sustainability under this heading of efficiency and substitution is about making the human ecological footprint smaller. The ecological footprint is one measure of ecological impact. Ecological footprint is a calculation of the amount of land needed to source the material for your life and to sink your wastes, year in and year out.
- The average American has a 24-acre ecological footprint, but the United States only has 9.6 acres available per person, so we run a deficit of 14.4 acres per person. Our ecological footprint currently is out of sight and out of our control. It also reaches all over the globe.
- This is unsustainable. We make up this ecological footprint deficit by harvesting resources faster than they regenerate, dumping carbon into the atmosphere instead of sequestering it, and using the productive capability of other, usually poorer, countries, often in the global south.
- If everyone used resources the way the United States does, we would need four Earths, and we only have one. Looking at the whole planet, there are 4.7 acres available for each person on Earth. This is called the fair-share ecological footprint.
- According to Dr. William Rees, who developed the ecological footprint methodology, we've been in ecological overshoot since about 1970. Overshoot means that the annual demand on resources

exceeds what Earth can regenerate. We are using up the Earth's resources at a greater rate than they can regenerate.

- One of the biggest challenges—if not the biggest challenge—to maintaining a small ecological footprint is the mindset that fossil fuels are a renewable resource. When we gauge tolerable distance, we think in terms of driving a car or flying a plane. But what if when we're thinking about buying a house, we asked how far it is to walk or bike to the closest grocery store instead of how far it is to drive?
- If we can get our human needs met locally and sustainably, we leave more of the planet for natural systems and the other life-forms we share the planet with. It is important that we live within the biophysical limits of the planet, starting living within the biophysical limits of our homes and neighborhoods—within a fair-share ecological footprint.
- To be sustainable, our reduced footprint not only needs to be small, but it also needs to be regenerative. What if the by-products of human activity were regenerative? Examples of regenerative by-products include wetlands, wildlands, and beauty.

Sustainability at Home

- Sustainability is about how we can celebrate nature's abundance and diversity to create a life that is regenerative in a physical sense, using solar energy, but that also regenerates and renews the human spirit, which is subject to its own laws of entropy and is regularly in need of regeneration and renewal.
- The best place to start thinking about sustainability is right at your front door. Whether you live on acreage in the country or in an apartment in the city, you can begin to make the shift to sustainable living. Sustainable living is a process, not an end goal. Our understanding of sustainability continues to evolve, and our lifestyle evolves with it.
- Some argue that New York City is the greenest place in the United States. People live in compact apartments, the shared walls resulting

in fewer materials to build and lower energy requirements. Most people can get their needs met by walking, biking, or using public transport and don't have a car.

- The proper urban context multiplies the benefits of green technologies. The cutting edge of sustainability is making dense urban and village environments the most attractive places to live.
- Nature is fecund and abundant. We have plenty for ourselves and for future generations if we use resources and energy wisely.
- The changes we need to make in our lives for sustainable living lead to a different way of life, a different way of thinking about the world and our place in it. But that doesn't imply a diminished quality of life.
- In the wealthy countries, we've gone past the point where increases in material wealth bring corresponding increases in human well-being. Increases in well-being in the industrialized countries come from developments in the other dimensions of sustainability, such as better relationships and a sense of purpose and meaning.

Suggested Reading

McDonough and Braungart, *Cradle to Cradle*.

———, "The NEXT Industrial Revolution."

Mollison and Slay, *Introduction to Permaculture*.

Wackernagel and Rees, *Our Ecological Footprint*.

Questions to Consider

1. In what ways does energy create order and structure in your life? Are the sources of energy sustainable?
2. How can you use the principles of sustainability to guide choices in your day-to-day life?

Sustainable Energy Options

Lecture 2

From a human perspective, the Sun is unimaginably powerful. The awesome forces of nature are powered by a daily dose of sunlight. The human economy can be powered by sunlight, too. Solar energy comes in many forms, including solar electricity, solar heat, wind energy, hydroelectric energy (energy from moving water), and biomass energy (energy derived from plants). The Sun is the driving force behind all these energy sources. The Sun heats parts of the Earth differently, causing the winds to blow, and the Sun drives the hydrologic cycle that is the basis of hydroelectric power.

Green Energy

- Financial benefits and satisfaction can come from using the green energy from the Sun that you capture at home. If the goal of sustainability is to meet the needs of the present generation without diminishing the ability of future generations to meet their needs, then in order to leave opportunities for future generations, we need a source of high-quality, concentrated energy to offset the effects of entropy.
- Solar energy is what nature uses to offset the effects of entropy. Plants take sunlight and create order and structure through biology. People also use solar energy. For the last hundred years, we've been using solar energy in the form of fossil fuels to power our economy.
- There is a limited supply of fossil fuels, however. Not only are they a finite resource, but we've also learned that burning them creates problems for us and future generations, including pollution and global warming.
- The direction in which sustainable living looks is to the Sun. Although the Sun is 94,000,000 miles away, it feels warm on the

side of your face and is too bright to look at. Every day, the Sun delivers 14,000 times more energy than the human economy uses.

- Energy flows around us in many ways, and we can make use of it as it flows from a high-quality source to a high-entropy sink. A high-quality source is a source of energy, such as the Sun, that is at a high temperature relative to its surroundings and is capable of doing many kinds of work. A high-entropy sink is where energy leaves the system, no longer able to do any useful work.
- A sustainable approach to life and community design focuses attention on the myriad ways in which energy is constantly and dependably flowing around us. There is energy all around us, flowing from source to sink in thousands of ways, and we can make use of it as it flows. We've just begun to scratch the surface of all the ways in which we can harness all this energy.

Using Energy Efficiently

- Using energy efficiently doesn't mean freezing in the dark. The goal is to use energy smarter, getting our hot showers and cold beer with far less energy than we do now. With off-the-shelf technology, it's possible to reduce energy consumption by 75 percent or more and still provide the same or better services.
- To use energy more wisely in your home, the first step is to figure out how much energy you use. What percentage of your monthly bill goes to lighting, electronics, or the fridge? What percentage provides no useful service to you at all? This takes some detective work.



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Using energy efficiently can help you save money on your energy bill.

- You can use a 20-dollar device called a Kill A Watt to help with this. The Kill A Watt plugs into the wall, and then you plug an appliance into it. The device measures the flow of energy into the appliance, and it's particularly useful for figuring out the total energy used by things like fridges that turn on and off all day long.
- Heating, cooling, hot water, refrigeration, and lighting use about 75 percent of a typical home energy bill. These days, we use a lot of electronics, but electronics use only about 10 to 15 percent of home electrical energy use.
- About two-thirds of the energy that flows through the economy is wasted. By using energy efficiently and putting the savings toward renewable energy, we can save enough money as a society to convert to solar energy, and we can do it at a profit.
- One way to maximize energy savings is to use an integrated design process. In an integrated design process, each element is evaluated for what it can contribute to the whole. In this way, larger energy savings sometimes cost less than smaller energy savings, cutting through the law of diminishing returns.

Generating Electricity from Renewable Sources

- There are three basic renewable energy technologies to consider for home use: solar electric, solar thermal, and wind. For most people, solar electric and solar thermal have the widest application.
- There are two basic kinds of solar electric systems: grid-tied and off-grid systems. Grid-tied systems put solar energy on the grid, offsetting energy you would have purchased from the power company. Ninety-nine percent of the systems installed today are grid-tied systems. Energy flows from the Sun to a solar panel, where it is converted into electricity.
- For a grid-tied system, in addition to solar panels, you need a device that matches solar panel output to the utility grid, called an inverter. The inverter plugs into your electrical system like any other

appliance, but rather than using energy from the grid, it produces energy from your solar panels and uploads it to the power grid.

- Grid-tied systems don't require regular maintenance or management. But they do have one disadvantage: When the utility grid is down, your system can't generate energy, even when the Sun is shining.
- If your main reason for installing a solar energy system is to have power during utility outages, you'll want a system that can operate independently from the grid. Grid-independent, or off-grid, systems require batteries that store solar energy for use at night and on cloudy days. In addition to solar panels and an inverter, you will need batteries and a charge controller.
- Off-grid systems are more expensive and require more management than grid-tied systems, but the solar power from an off-grid system isn't limited by existing infrastructure or the needs of electric companies, so you can get energy where utility power is not available.
- Where utility power *is* available, you can disconnect completely, or you can remain hooked to the grid. Staying hooked to the grid allows excess energy generated by your system to be used by others on the grid. The grid can also be used as backup when the Sun isn't shining.
- An off-grid system connects you to the flow of energy in nature in ways that a grid-tied system can't. The disadvantage is that this requires more management and the careful use of energy in times when it isn't sunny.
- For years, we've been waiting for the price of solar technology to drop. Since 2010, the price of solar panels has plummeted by a factor of three. The good news is that solar electricity is now affordable for many, with three- to 15-year paybacks.

- In some areas, companies will install solar energy systems on your roof with no up-front cost. They make money by selling you the power at a discount from utility rates. Solar panels convert energy from the Sun into electricity with no moving parts. Nothing is used up in the process. Solar panels last a long time and often have 25-year warranties.
- The breakthroughs we have been waiting for are here: Solar energy is now cheap, reliable, and in use on millions of rooftops, even in areas of the world that only get half as much solar energy as the United States, such as Germany.
- You can put enough solar electric power on your roof to offset your electric bill; the solar electric system will pay for itself in utility bill savings. It's possible to save enough money on your bill through efficiency to pay for the monthly payment on a solar energy system.
- Many people have installed systems themselves, and thousands of companies have sprung up to meet the demand for solar energy. If you don't want to do it yourself, chances are that you can find someone qualified to set up solar energy systems near where you live.
- You can use a different kind of solar panel to make hot water for things like bathing, washing, or heating a pool. In the past, this was the most economical way to use solar energy. You got more energy per dollar with this technology than any other. With the drop in price of PV solar panels, it is not clear that this is still the case.
- Solar hot-water systems use your existing hot-water heater for backup, so you can have hot water when the Sun isn't shining. Heating pools with solar energy often has a short payback, about three to five years. You can also use solar hot water or air panels to heat your home with the Sun. Other ways to use solar thermal energy include water purification and solar ovens for cooking.

- The Sun heats parts of the Earth differently, causing wind to blow. Often, when the Sun isn't shining, the wind is blowing. Wind energy is an excellent complement to solar energy.
- Wind energy is not as evenly distributed as solar energy, and you need a tall tower to capture the wind. Using a short tower is like putting solar panels in the shade.
- Some companies make wind turbines that operate like grid-tied solar electric systems. If you have a very good wind site (which is rare), you can sometimes get more energy per dollar invested with a wind system.
- Other disadvantages with wind turbines are their moving parts and an inconvenient location—high in the air. There are far fewer small wind turbines than solar electric systems, and there are only a few manufacturers that have built more than a few hundred machines. Most, but not all, wind energy machines on the market today are really prototypes that are bound to have reliability problems.
- Some utilities offer programs that, for a fee, provide energy backed by wind power. The energy comes from large wind projects that the utility has invested in. Using one of these programs to complement a grid-tied solar system means that even the energy you take from the grid supports the use of renewable energy.

Tips for Home Renters

- If you rent, have a very shady yard, or can't put a solar energy system on your home for any of a number of reasons, there are a few ways you could still use solar energy. For less than 500 dollars, you can build a small system that will power lights, home electronics, and a few appliances.
- The solar panel could be mounted outside a window or on a porch. You'll get maximum energy if it faces south, but it can still work well facing other directions; however, avoid north because the Sun spends most of its time in the south, east, and west. This is an

excellent way to learn about the technology, and you can take it with you or sell it when you move.

- Another simple way to use solar energy is to charge your cell phone with solar energy. Connect a small 12-volt panel to a car cigarette lighter USB charger. Plug your phone into the USB port, and then put the panel in the Sun.
- Another way for a home renter to support sustainable energy sources is to pay a special rate to the utility to support renewable energy. Some utilities allow you to pay a special rate for power, usually higher, that goes to support renewable energy.
- Furthermore, you can join a community solar garden—solar panels installed in a central location—if you are lucky enough to live where they are allowed. You can buy as few as one panel, and someone else installs and maintains it for you. You can sell it if you move. The output of the panel is billed as if it were installed at your house. It offsets what you would have purchased from the utility in the same way as if it were installed on your roof.
- You can even cook with solar energy, using a solar oven. Other sustainable energy options to explore include solar building design, heating and cooling, transportation alternatives, and solar hot water.

Suggested Reading

Chiras, *Power from the Sun*.

Lovins, *Reinventing Fire*.

Peet, *Energy and the Ecological Economics of Sustainability*.

Randolph and Masters, *Energy for Sustainability*.

Vaitheeswaran, *Power to the People*.

Questions to Consider

1. Why is solar energy central to sustainability?
2. Which would you do first: improve the efficiency of your home or power it with solar? Why?

Sustainable Building Choices

Lecture 3

Buildings and cities have a huge impact on human well-being and sustainability. The biggest part of our ecological footprint comes from the built environment. Buildings consume 50 percent of the energy and 75 percent of the electricity that flows through the U.S. economy, and they use 40 percent of all raw materials globally. About 14 percent of all potable water is used in buildings annually, and about 40 percent of greenhouse gases are sourced from buildings. In this lecture, you will learn how we can build buildings that are regenerative, that give back more than they take, that are sustainable.

Green Buildings

- On average, Americans spend 90 percent of their time indoors. Buildings and cities have a huge impact on our comfort and well-being. Green buildings—with lots of natural daylight, nontoxic materials, and superior levels of air quality and thermal comfort—can have a big impact on well-being and productivity. In addition to the impact on the people who live and work in the built environment, buildings also have a huge impact on sustainability through energy and material use.
- The good news is that we can design buildings that produce more energy than they consume, harvest rainwater from the sky, are filled with natural daylight, and are built of nontoxic materials. Buildings can be designed to be recycled when their useful life is over. We can do this for about the cost of building conventional buildings of the same quality.
- The American Institute of Architects has adopted a plan called Architecture 2030, whose goal is to transform the built environment from the major contributor of greenhouse gas emissions to a central part of the solution to the climate and energy crises.



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The goal of sustainable development is to create energy-efficient, nature-friendly, comfortable buildings.

- Architecture 2030 calls for all new buildings to be net energy producers—meaning that the building produces as much or more energy than it consumes on an annual basis—by 2030 and for the renovation of older buildings to conform to these standards.
- Once energy demand is reduced, it's cost effective and practical to supply the smaller energy demand with solar panels and wind generators. In general, one way to lower the ecological footprint of a house is to make it smaller.
- Do green buildings cost more? It varies widely. Typically, there is a 10- to 20-percent premium for building a high-performance building. Green buildings use better-quality, long-lived materials that sometimes cost more up front. But that increased cost is paid back in terms of increased comfort, energy savings, water savings, and decreased maintenance costs—just as with the solar panels for solar energy.

- There are two basic approaches to green building: natural building and high-performance conventional building. Natural building uses locally available, lightly processed materials. High-performance building uses conventionally available materials and building science to create buildings that require very little energy to heat and cool.
- The best buildings are 100 percent solar heated and cooled. By design, they use 75 to 90 percent less energy than conventional buildings.
- Some natural buildings are not high-performance buildings; they take considerable amounts of energy to heat and cool. And some high-performance buildings are not made with natural materials.
- Natural building uses lightly processed, locally sourced materials, such as straw bale, cob, rammed earth, adobe, wood, and stone. Earth plasters can be used for walls and floors. Some combination of clay, fibers like straw, and sand are common ingredients in natural building. Often, these structures are built by the owner or involve a community building effort.
- Both insulation and thermal mass are useful in sustainable building design, but they have very different functions, and you can't substitute one for the other. Insulation blocks the flow of heat in or out of a building and is typically made of light, fluffy materials. It's like wrapping a building in a down comforter.
- Thermal mass stores energy as it rises in temperature and releases it as its temperature drops. It's used to keep a space from overheating during the day, storing excess solar heat for release into the space at night. Thermal mass materials are dense and heavy, like rock and concrete.
- High-performance building uses conventional materials that, for the most part, will be familiar to building contractors and available at your local building supply store. Most building contractors

can adapt to the novel ways these materials are used in high-performance building, but it's best to find a builder that is educated about and committed to it.

- High-performance building combines intimate knowledge of the climate, the site, the materials, and building science to create buildings that require very little energy to heat and cool.

Passive Solar Design

- When creating a high-performance building, start with the green features you can get for free. Passive solar design uses common building materials to collect and store energy and provide abundant natural light and ventilation. It's passive solar because there aren't any pumps or fans used to move the energy.
- Common building materials—such as windows, wood, and massive materials like concrete—can be placed in such a way that the building, by design, collects and stores solar energy in the winter and rejects solar energy in the summer. This makes optimum use of the energy that flows over your site in all seasons.
- It's mostly free, because it's just a more intelligent approach to placing building materials that, for the most part, you would have used anyway. You trade more intelligence in design for less building energy use.
- It's important to consider passive solar in the early stages of design because obviously it's difficult to change the orientation, shape, window placement, and insulation levels of a building after it's built.
- The following are some tips for making passive solar energy a reality in your home. These guidelines apply mostly to new construction.
 - Build a rectangular shape and orient the long side east to west. This maximizes solar exposure for winter and minimizes exposure for summer.

- Favor window placement on the south to maximize solar gain. Windows need an overhang that is sized to block the high summer sun and allow the low winter sun to penetrate deeply into the building.
- Having ten to fifteen percent of building floor area in south-facing windows is about right. You can overdo this, causing the building to overheat during the daytime and lose too much energy at night, so pay attention to your measurements.
- Locate heavy materials like concrete and tile where the Sun will shine directly on them to help store solar energy for use at night.
- The Sun spends a lot of time shining on the west side of a building during the summer. Minimize windows on the west to avoid heat gain in the summer.
- Daylighting is the art and science of lighting buildings using sunlight. For daylighting, windows need to be placed to allow indirect sunlight into the room. Direct sunlight is too intense. Daylight windows are often placed higher, with view windows at a lower level.
- You will have to spend a little extra money on insulation. For the colder parts of the United States, you want about 12 inches of wall insulation and 20 inches of insulation in the ceiling/attic. The extra money you spend on insulation can often be recouped through savings in downsizing or eliminating the furnace.
- Seal the building tightly, and provide fresh air using an air-to-air heat exchanger, which allows the heat in exiting warm air to be passed to incoming cold air, allowing abundant fresh air with minimum energy penalty.

Energy Conservation versus Energy Efficiency

- There is a difference between energy conservation and energy efficiency. Energy conservation is doing less with less: having a colder house to save energy and freezing in the dark. You might also want to consider modest lifestyle changes (energy-conservation measures), such as wearing a sweater and adjusting the thermostat higher or lower.
- Energy efficiency is doing more with less: having a more comfortable house that uses less energy. You still have hot showers and cold beer, but you are smarter about how you heat the water and cool the beer.
- To take energy-efficient measures, start with a professional, high-level energy audit. This is different than most free walkthrough audits offered by utility companies. Expect the audit to take most of a day and cost about 300 to 500 dollars. You'll get a prioritized list of options for improving energy efficiency and comfort, as well as an estimate of energy savings for each option.
- What can you do with what you have? How can you retrofit a home or apartment for sustainable living? Retrofitting an existing home to a high-performance standard can be difficult and expensive. Some ideas to retrofit your existing home include cutting down air leakage, adding insulation, replacing windows, improving the efficiency of your heating and cooling system, and conducting a combustion efficiency test.
- To cut down air leakage, apply weather stripping. Often, utility companies have incentives to help pay for this. Caulk around windows, put on seasonal storm windows, and weather-strip around doors. Seal holes in your house; seal around pipes, wires, electrical outlets, and other penetrations.
- Attics are easy places to add more insulation. Aim for r-60 in the attic and r-40 in the walls. R-value is a measure of the ability of a material to block the flow of heat. Higher numbers are better.

- Cellulose, made from old newspapers, is a common attic retrofit insulation. Attic insulation is a good do-it-yourself project, and most places that sell cellulose insulation will loan you the machine that blows it into the attic. Be sure to seal up any air leaks from the house into the attic before adding insulation.
- If your house is old and doesn't have any insulation in the walls, you can blow cellulose or foam into the walls. Unlike attic insulation, though, wall insulation is best done by an experienced installer.
- Replacing windows can be pricey, so consider insulation first.
- To improve the efficiency of your heating and cooling system, seal heating and cooling ducts.
- Check to see if your furnace is operating at peak efficiency with a combustion efficiency test. It's also important to check that sealing air leaks doesn't trap combustion gases in your home.
- Retrofitting an existing home is not easy. The most efficient way of doing so is an area of continuing research.

Alternative Heating Systems

- There are alternatives to furnaces when it comes to heating systems. Wood is stored solar energy and makes a good backup heating source for passive solar homes. Modern wood burners are efficient and burn clean.
- If you use solar electricity, consider mini-split heat pumps, which take one unit of electricity and produce up to three units of heat, as well as provide high-efficiency cooling.
- Ground source heat pumps are expensive at the small capacities needed for low-energy homes but can work well for larger buildings. Ground source heat pumps use the stable temperature of the Earth at depths of eight feet or more to provide heating and cooling.

Suggested Reading

Chiras, *The Natural House*.

Johnston and Gibson, *Green from the Ground Up*.

Owens, *Building with Awareness*.

Snell and Callahan, *Building Green*.

Questions to Consider

1. Why is the built environment (cities, roads, and buildings) important for sustainability?
2. Why is the design phase a critical time in the life of a sustainable building?

Cultivating Sustainable Landscapes

Lecture 4

We are used to thinking about getting food from a garden, but there is so much more that sustainable, functional landscapes can do. Sustainable landscapes are those that work within natural cycles of soil fertility and rainwater, without toxic chemicals. They are functional because they are not only beautiful, but they also provide for human needs. Landscapes can be designed to provide a wide variety of products and services for humans and wildlife. In this lecture, you will learn about sustainable landscapes.

Sustainable Landscapes

- The following is a list of some of the things our landscapes can provide our households, and those of our neighbors, if we design them to do so.
 - Herbs for use in teas, tinctures, creams, and salves
 - Craft materials, such as basketry and weaving materials, beading materials, and soaps
 - Paints and dyes
 - Glues and adhesives
 - Water services, infiltrating storm water and purifying polluted waters
 - Perfumes and fragrances
 - Building materials, such as bamboo, willow, and lumber
- A well-designed, functional landscape can also attract or repel wildlife, beautify your home's surroundings, help meld the inside

living space with the outside (increasing the amount and quality of space in our homes), and screen out unwanted views or noise.

- Permaculture is an attempt to design human habitats that have the stability, diversity, and resilience of natural ecosystems. It was developed by Bill Mollison and David Holmgren in Australia and has a strong emphasis on creating landscapes around homes and cities that meet human needs.

The Soil Food Web

- The first step on your path to creating a sustainable landscape is to look at your soil. Soil is a complex mixture of minerals, organic material, water, and life; it is the foundation of the web of life. We're used to thinking of soil as a lifeless substrate for growing plants. We treat soil like dirt.
- Dirt is inert. But healthy soil is teeming with life. A single teaspoon of soil holds up to one billion bacteria, several yards of fungal filaments, several thousand protozoans, and scores of nematodes. These microorganisms are supplemented by larger creatures, such as worms and millipedes.
- When organic matter and soil pass through earthworms' guts, nutrients are put in a form that is readily absorbed by plant roots. Castings, or worm excrement, are a mix of soil, beneficial microorganisms, and organic substances that are beneficial to plants. They're a great plant fertilizer and soil enhancer.



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To create a sustainable landscape, the first step is making sure that your soil is healthy.

- Worms create tunnels that allow for water, air, and root movement in the soil. Worms incorporate organic matter deep into the soil and move buried nutrients closer to the surface. An acre of land can contain up to one million earthworms. A ton of cows in a field depends on several tons of earthworms below the surface.
- To encourage earthworms in your soil, provide organic matter for them to eat, preferably applied as a surface mulch. Worms love newspaper, so recycle your newspapers in the garden as mulch or shred it for the compost pile. Worms need undisturbed soil. You can gently aerate soil with a broadfork, but aggressive tilling is not good for luring worms.
- Research on the soil food web in the last 20 years has demonstrated that plants get what they need to be healthy through their relationships with life in the soil. Plants take sunlight and create complex chemicals, such as carbohydrates. Soil microorganisms cooperate with plants by converting soil nutrients into the forms plants need in exchange for complex carbohydrates the microbes need.
- The sustainable approach to soil fertility is to take care of the life in the soil, and then the life in the soil takes care of the plants.
- What can you do if your soil is deficient in soil life? The simple answer is compost and organic matter. Learning to make good aerobic (in the presence of air) compost, teeming with beneficial microorganisms, is a key skill in sustainable gardening.
- Compost and organic matter are the keys to healthy soil life and good soil tilth. Good tilth means that the soil has structure that encourages plant growth.
- Aerobic compost teas and extracts can make a small quantity of good compost go a long way. Good compost teas can be sprayed on leaves to control diseases. The beneficial organisms colonize the leaf surface and out-compete the disease-causing organisms.

- The compost process generates heat as a by-product. It's possible to make use of this heat for hot water, buildings, or greenhouses.

Sustainable Plant Selections

- When creating your sustainable landscape, you will need to select varieties that can withstand the winter temperatures in your location. The USDA has established plant hardiness zones that range from zone 3 (coldest) to zone 10 (warmest) in the continental United States. Plant hardiness zone ranges are available for most plants through a variety of sources.
- With global warming, the warmer zones have been creeping steadily farther north, with a remarkable difference between the 2000 and 2010 maps, so be sure that you're planning from an up-to-date zone map.
- There are two basic kinds of plants for your landscape: annuals, which need to be planted from seed every year; and perennials, which are planted once and then provide a yield for years. There is also a kind of hybrid: annuals that self-seed heavily and come back every year like perennials.
- Most vegetables in the grocery store are annuals. Most fruits and nuts are perennials. Sustainable gardening puts a focus on perennials as a way to maximize the results you get from the effort you put in to gardening.
- Perennial plants have deep roots compared to annuals. Deeper roots mean resistance to drought and the ability to access nutrients deeper in the ground. Deeper roots can take advantage of a wider scope of soil.
- The Land Institute in Kansas is working to develop perennial versions of all the main grain crops, including wheat, sunflower, rice, and corn. Perennial grains would allow grains to be grown in perennial polycultures, mimicking the prairie. Polycultures are groups of plants that have a synergistic effect when grown together.

For example, growing a nitrogen-fixing plant like clover along with wheat minimizes the need for nitrogen fertilizer.

- Monocultures, or monocrops, are plantings that feature just one species. Monocrops tend to be more susceptible to disease and insect problems. Most natural ecosystems are diverse polycultures.
- One of the problems with our commercial approach to agriculture has been its focus on monocrops and monocultures. It's a perfect example of working against natural principles rather than with them. Sustainable agriculture focuses on polycultures for these reasons.
- Although most of the perennials that are familiar are berries, vines, fruits, and nuts, there are a surprising number of perennial vegetables, some of which are more familiar than others, including asparagus, sorrel, artichokes, Good-King-Henry, daylilies, and Jerusalem artichoke.
- Many herbs are perennials in most parts of the United States or self-seeding annuals, including chives, garlic chives, thyme, and French tarragon. In addition to their return each year, another advantage to planting perennials is that they get a head start in the spring, extending the season.
- Trees can require a lot of work. They need to be mulched, fertilized, and protected against insects and disease. What if we could get the needs of the tree met instead by other plants? A group of plants that work together to meet mutual needs is called a guild, which typically has a central plant and a group of plants that cooperate to meet the needs of the central plant.
- Guild plants should include the following. (Note that Comfrey is a superstar guild plant: It's a dynamic accumulator, a prolific mulch plant, and a grass border.)

- A nitrogen-fixing plant, which takes nitrogen from the air and makes it available to the main plant. Nitrogen-fixing plants include beans, clover, and trees like honey locust.
- A mulch plant provides mulch to conserve water and smother weeds. Comfrey can be cut back for use as mulch several times each season.
- Insectary plants attract beneficial insects and repel damaging ones. Members of the Umbelliferae family—such as fennel, coriander, dill, Queen Anne’s lace, and wild carrot—attract predatory wasps.
- Grass border plants keep out grasses, which have a negative effect on fruit tree growth. Comfrey and daylilies can be planted in a ring around fruit trees to keep out grasses.
- Dynamic accumulators mine nutrients deep in the soil, and when you mulch with them, they make the nutrients available at the surface. Comfrey is a dynamic accumulator of calcium, an important plant nutrient.
- The principle of ecological design at work here is to use biological systems rather than mechanical ones whenever possible, because biological systems can use sunlight to self-organize.
- There are a wide variety of unusual fruits for the home garden, including pawpaw, American persimmon, and jujube (Chinese date). Many of these fruits have superior flavor and nutrition than commercial varieties, but they have characteristics that make them difficult to grow commercially, such as not shipping well. The only way you can enjoy many of these fruits is to grow them yourself.

Tips for Limited Space

- What if you don’t have room for fruit trees, live in an apartment, or rent? You can grow a surprising variety of fruits in containers, and

you can grow fruits that are tender for your climate and bring them inside in the winter.

- You can also consider supporting the planting of public fruit trees in your community if you want to cultivate fruit but don't have the room for trees.
- If you have a yard full of ornamental fruit trees, you should know that ornamental fruits can be grafted so that they yield full-size fruits. Grafting results in one tree with two different varieties of fruit, maybe one that bears early and one that bears late.
- Trees that are going to be grafted need to be closely related, so apples will graft onto apples but not onto pears. While the details of grafting can be complex, the basics skills are pretty easy to pick up.

Wildcrafting

- Another way to connect with your food is to learn about the wild edible plants and mushrooms that grow where you live. Of course, you need to be careful with mushrooms, because some deadly species resemble edible ones.
- Common wild edibles include lamb's quarters, dandelion, cattail, and burdock. Do some research on the Internet to learn about wild edibles in your area and how to use them.

Suggested Reading

Fern, *Plants for a Future*.

Hemenway, *Gaia's Garden*.

Ingham, "Natural Resources Conservation Service."

Lowenfels and Lewis, *Teaming with Microbes*.

Reich, *Uncommon Fruits for Every Garden*.

Toensmeier, *Perennial Vegetables*.

Questions to Consider

1. Why plant functional landscapes?
2. What are some needs that you could meet with plants you could grow in your neighborhood?
3. What is the relationship of plants with life in the soil?
4. Discuss the relative advantages and disadvantages of using perennial plants instead of annuals.

Fresh Food from Your Own Garden

Lecture 5

In this lecture, you will explore a wide variety of options for becoming more involved with your food as it travels from seed to fork. Food is always better when it is fresh, and the best stuff is grown at home. You will learn simple methods for growing something fresh for your table every day of the year, even if you live in an apartment in the city. You also will learn interesting ways to mimic nature to start productive gardens that require only a few hours of enjoyable labor per week to establish and maintain.

Getting Involved with Your Food

- Growing your own food can be one of the most satisfying activities that you engage in. You learn firsthand about sustainability by engaging, even in a small way, in the cycles needed to produce some of your own food.
- One of the most important decisions you will make about growing food is what scale to start with. It's always better to start small and get a satisfying yield. This is a principle of ecological design: Start small and build on success. You can expand as your skill and confidence develop.
- Have a goal that you eat something you grow every day. This might mean just a sprig of parsley for your soup or a handful of sprouts.
- What you grow should be located in a place you pass by several times a day so that it's in the flow of what you do and not something that requires a lot of extra effort. The ability to regularly observe what is going on with your mini-farm is important to the pleasure you get and the overall success of the project.
- This is another principle of ecological design: Place design elements that require more attention in areas visited most often. Place your

garden where you'll pass by it—maybe near the front door of your home or the door near your kitchen.

- There are many different gardening philosophies with strong adherents and good results. John Jeavons and his colleagues at Ecology Action developed one such philosophy. They have spent 40 years developing an elegant, small-scale farming and gardening system called GROW BIOINTENSIVE.
- When practiced correctly, this gardening system nurtures healthy soil, produces high yields, and conserves resources. Gardeners and small farmers have used it worldwide. Jeavons's methods derive in part from the intensive market gardens that developed around Paris in the 18th, 19th, and early 20th centuries.
- Another popular gardening philosophy and method is square foot gardening, explained in a series of books by Mel Bartholomew.
- Eliot Coleman takes a simple, no-nonsense approach to organic, sustainable gardening. In his book *Four Season Harvest*, he details his breakthrough methods for growing in what is normally considered the off-season: fall and winter. He takes an approach that involves feeding the soil, not the plant, and focuses on plant health to minimize disease and insect problems.

Low-Maintenance Gardening

- If you have a yard with a lot of grass on it, establishing a garden on what was previously lawn can be a lot of work. But there is a way to establish a garden in a few hours of easy work, without pulling up the grass or digging.
- With the method of gardening known as sheet mulching, mulch gardening, or no-till, you may not have to water or weed for the entire season. This method also been called lasagna gardening because the bed is built in layers, like lasagna.

- Compared to conventionally tilled gardens, this method is better for the life in the soil. Different soil microbes like different depths in the soil. Tillage mixes up the soil layers, causing microbes to have to reestablish themselves at their preferred depths.
- For a 4-by-8-foot garden, you need the following materials.
 - Cardboard to cover the area, including a 3-to-6-inch overlap between pieces. This is a great way to recycle the cardboard boxes you receive in the mail.
 - Compost or manure to cover the area 3 to 4 inches deep.
 - Straw, hay, leaves, or other mulch material to a depth of 6 to 12 inches.
- The following steps will help you get started on creating this type of garden.
 - If the grass is tall, either push it over or cut it short (leave the clippings on the ground; don't bag them up).
 - Cover the grass with 1 inch of the compost.
 - Cover the compost with cardboard, overlapping 3 to 6 inches.
 - Add 2 to 3 inches of compost on top of the cardboard.
 - Cover the compost with 6 to 12 inches of mulch. It will reduce after a rain or two.
- That's all you have to do. There's no tilling involved—just pile the stuff on top of the lawn. It will suffocate the grass and enrich the soil.
- It's easier to use starts or seedlings rather than seeds in a garden like this.
- Once you have built the garden, you can plant in it immediately. To plant, pull the mulch aside, cut a hole in the cardboard big enough

to fit your plant, and plant in that hole. Pull the mulch back around the plant.

- You'll want to water it well after you plant, but after that, check before you water. Chances are that the mulch and hay will keep enough moisture on your plants without watering. That's one of the benefits of this type of gardening.
- Earthworms will eventually eat the cardboard layer, tilling the soil for you as they do. The cardboard provides a barrier to weeds. If weeds do pop through, just smother them with mulch.
- In the second year and subsequent years, just add 6 to 12 inches of mulch material to the top of the garden and plant right into it. You can use mulch gardening to compost your kitchen scraps simply by slipping them under the mulch layer.
- Conventional garden thinking often involves figuring out what more we can do in the garden to improve productivity. No-till advocates take an approach to gardening that considers what *less* you can do. For answers, these gardeners observe nature to see what additional garden tasks can be turned over to natural systems. It turns out that tilling is one of those tasks we can turn back to nature.
- With gardening, start small, obtain a satisfying yield, and then build on your success. It's pretty difficult to keep up enthusiasm for something unless you get a yield.
- If you have never gardened before, try starting with a 4-by-4-foot or 4-by-8-foot garden. Even a garden this small will yield something fresh for the table all summer, and you can easily cover it with a simple greenhouse to extend the season into the fall and winter.
- To obtain a satisfying yield, pick things that do well in your area, and learn to like them. If you have trouble enjoying what grows best in your area, check out a few popular cookbooks and learn some new ways to prepare your garden yield. Often what we think

we don't like is badly prepared. Growing and eating fresh food is often an entirely different experience than eating preserved food or even produce shipped in and bought from the store.

Nurturing Your Plants

- Once you've planted a nice variety of plants that thrive in your area, how do you nurture them? Keep plants healthy with a vibrant soil food web, avoid monocultures, and rotate crops from year to year. These simple and sustainable practices go a long way toward minimizing problems.
- Pay attention to the amount of sunlight your plants get, and make sure that they get the right amount of water.
- If you do have problems, then there are a number of organic remedies, many of which you can whip up in your kitchen. Water and soap will control aphids. A solution of water and garlic in a blender is good for a variety of plant problems. Many nonpoisonous, natural solutions for specific problems can be prepared from herbs and other supplies in your kitchen.
- Build habitats for a wide variety of beneficial insects. Your garden should include not only the plants you grow to eat, but also some plants that will attract insects for pest control and pollination.
- The herb dill, for example, will attract beneficial wasps that are not harmful to people but are very helpful for controlling pests. You can dig a small pond and stock it with goldfish—if you don't feed them, they'll snack on mosquito larvae. The pond will also provide a habitat for frogs and other amphibians that will patrol your garden for insects.
- Put up birdhouses and plant flowers to attract birds to your garden. They'll snack on insects as well as add beauty and song to your yard. Bats also help with controlling insect pests. Consider installing bat houses to attract bats to your garden.



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If you live in an apartment with limited space indoors, consider starting a garden on your rooftop and encouraging your neighbors to contribute.

Container Gardening

- If access to a garden plot is limited, you can start growing in containers. You can grow a wide range of vegetables and fruits in containers, including lamb's-quarter, also known as chenopod, a common weed. You can use it in cooked dishes in the same way you would use spinach, and it makes an excellent pesto.
- The following are some tips for growing in containers, which requires no planting, fertilizing, or watering.
 - Make a soilless mix. The soil in containers can get easily compacted, so it's important to have a loose, well-drained mix. For example, you can use 50 percent peat moss or coconut coir, at least 25 percent compost, and 25 percent vermiculite or perlite (expanded lightweight rock that keeps the mix well drained). Depending on the requirements of the plant, you can add lime, rock powders, and an organic fertilizer. In most cases, it's better not to use soil.

- Water properly. A common cause of failure in container gardening is overwatering. Use automatic watering systems when possible.
- Get creative with the use of containers. You can make containers from recycled materials or buy inexpensive ones from a nursery.
- Grow kitchen herbs that are especially good fresh, such as basil and parsley, in containers in the kitchen or as close as possible. Rosemary is another herb that works well in a container. Keep them close by, along with a pair of scissors, so that you can grab a handful and toss them into your cooking.
- Use containers to grow fruits that won't grow outside, such as figs and grapefruit in certain climates. Citrus and bananas both can be grown in containers outside in summer and brought in during winter.

Community Gardens

- If you don't have anywhere to put containers, many cities have community garden space where you can rent a small plot for a nominal fee. Look for programs in your city or band together with friends and neighbors on a vacant lot.
- Even if you live in the city, you can add richness to your life through joining a Community Supported Agriculture (CSA) program or shopping at the farmer's market. With a CSA program, you pay a subscription fee to a farmer in exchange for a weekly box of whatever is fresh and ripe.
- You can add agritourism to your vacation and travel schedule. Visiting a small food producer or farmer adds richness to your vacation and travel plans. Some farms and producers provide a short tour and sampling of wares; others provide lodging and meals straight from the farm.

- Many cities are creating new ordinances that allow small livestock, such as bees and chickens, in urban areas. Bees help with pollination as well as provide honey.
- If you discover that you like growing food and are good at it, you may want to consider growing extra for sale at the market or even becoming a full-time farmer.

Suggested Reading

Bartholomew, *Square Foot Gardening*.

Coleman, *The New Organic Grower*.

Damrosch and Coleman, *The Four Season Farm Gardener's Cookbook*.

Fukuoka, *The One-Straw Revolution*.

Jeavons, *How to Grow More Vegetables*.

Jeavons and Cox, *The Sustainable Vegetable Garden*.

Lanza, *Lasagna Gardening*.

Reich, *The Weedless Garden*.

Stout, *How to Have a Green Thumb without an Aching Back*.

Activities

1. Investigate how you could be more involved with the food producers in your community. If you already go to a farmer's market, visit one of the farms you buy from. Use the Internet to search for farms, CSAs, cheese producers, chicken and meat producers, and vineyards and wineries.
2. Prepare a list of what is available locally through the seasons in your area, including things that can be easily stored, such as potatoes and winter squash.
3. Research the wild plants, native fruits and nuts, and neighborhood fruit trees in your area, and then go out and find them.

Winter Gardening

Lecture 6

Summer provides an abundance of fresh, local produce. But what if you want something fresh for the table in the off-season? Growing off-season in cold climates is one of the most stunning developments in growing food locally. In this lecture, you will learn how you can harvest something fresh for your table all winter long using simple technology that extends the season from fall to spring. And you don't need a fancy greenhouse; you can build a simple, inexpensive structure that will allow you to harvest in the off-season.

Off-Season Gardening

- There are three main factors to consider when growing in the winter: plant selection, light, and heat. In the winter, you can't grow heat-loving, warm-season crops like tomatoes, eggplants, and peppers with normal methods. About 30 plants, mostly hardy greens, have been identified that do well in winter production, including arugula, mâche, lettuces, escarole, beet greens, leeks, carrots, kale, and tatsoi.
- One approach to trying to grow warm-season crops in the winter is the bioshelter concept. These greenhouses have insulation on the east, west, and north—only the south is glazed. They often use compost or animals in the greenhouse to help raise the temperature. They are sunk into the ground. Sometimes, they are even designed for people to live in them.
- In the 1980s, Chinese farmers developed an unheated greenhouse that allowed them to grow warm-season crops in the winter. These greenhouses now cover thousands of acres in China. The application of these types of greenhouses in the United States is an area of active research.
- These systems have a few things in common: They are expensive, and they fight nature rather than working with it. But you can make

a much simpler system using the philosophy of working with nature rather than fighting it.

- In the simple systems, you are not doing battle with the cold of winter as one thinks of doing in a heated greenhouse, trying to grow warm-weather crops. Instead, you're creating a simple protected microclimate that is sufficient for the needs of plants that don't mind the cold—hardy plants.
- In addition to heat, plants require a minimum amount of light for vigorous growth. The good news is that most areas of the United States have sufficient hours of daylight in the winter for successful winter gardening. Most of the United States gets more hours of winter sunlight than most of Europe, where there is a tradition of winter growing.
- When the number of hours of daylight drops below 10, plant growth slows considerably. But if you get plants to harvestable stage before then, you can harvest their leaves. Regrowth will be slow until day length goes above 10 hours. You are not extending the growing season in the same way you would with a heated greenhouse—you are extending the harvest season.
- There are two tricks to off-season growing.
 - A simple unheated greenhouse and cold frame technology, supplemented with floating row covers. This can be done on a wide range of scales, from small backyard structures that cost less than 100 dollars to build to large commercial operations with acres of greenhouses.
 - The selection of plants and the timing of planting and harvesting.

Structures for Off-Season Gardening

- Just as we build structures for people in cold climates, we need to build structures for plants. The rule of thumb is that every cover over your plants moves them one USDA zone (about 300 miles) farther south. But every cover blocks light.

- For most of the United States, two covers are about right. The first cover is plastic or glass, and the second cover is a special lightweight fabric that rests gently on the plants or on supports just above the plants.
- Floating row covers go by several brand names. Unlike plastic, floating row covers let in moisture and air and transmit up to 90 percent of the light. In the early stages, you can put the cover directly on the plants. Once freezing weather starts, it's better to support the row cover over the plants with simple wire hoops.
- There is a wide range of structures for off-season growing. You can build a simple structure that will allow you to grow in the off-season, using parts you can scrounge or find in your local building supply store. The following materials and tools are needed to make a 4-by-8-foot mini-greenhouse, but you can modify the size to meet the space you have available.
 - 2 boards, 2 by 10 by 8 feet
 - 4 boards, 2 by 2 by 10 feet
 - 1 10-by-10-foot 4 or 6 mil plastic sheeting (Note: If you have to buy a bigger piece, then you'll have a lot of extra for future years or to share with friends.)
 - 4 ½-inch electrical conduits (EMT)
 - 16 2-hole straps for conduit
 - 12 2½-inch screws, #8
 - 32 1-inch screws
 - Electric drill
 - Wood saw (or have the lumber yard cut the board for you)

- Hoop bender (if you are using ½-inch electrical conduit)
- Utility knife or scissors for cutting plastic
- Tape measure
- Permanent marker
- Note that you will have to buy extra of some items; they come in packs that have more than you need. Use the extra by getting your gardening friends together and having a mini-greenhouse-making party.
- You'll need hoops to hold the plastic over the plants. You can attach the hoops to a simple raised bed frame or put the hoops directly in the ground in your garden.
 - Build the frame from 2-by-8 wood or taller.
 - Next, build the hoops. You can use a wide variety of materials for hoops. If your garden is in a sheltered spot, you could use stiff wire, #9 is about right. Galvanized wire will resist rusting. You could also use plastic conduit. If you live in a region that has strong winds and violent weather, use ½-inch metal electrical conduit, also called EMT, instead of wire or plastic hoops. EMT is inexpensive, and it's easy to get at hardware and building supply stores.
 - Bend the 10-foot lengths of EMT pipe into hoops with a special bender. The bender costs about 40 dollars and could be used to make thousands of hoops. For this structure, use 4-foot-wide hoops. You can also get benders to make 3-foot- to 6-foot-wide hoops.
 - Mount the bender on a sturdy table, such as a picnic table or a small workbench. Place a mark 16 inches from each end of the pipe. Place the conduit in the bender and slide up to the 16-inch mark. Bend until the conduit just reaches the holder at the other end of the bender. Flip the conduit around, slide it in to

the 16-inch mark, and bend the other end. Take the pipe out of the bender, grab both ends, and gently squeeze the ends toward each other to complete the bend. Once you get the hang of it, it only takes a minute or two to make a bend.

- Next, attach the hoops to the frame using the 2-hole straps and 1-inch screws.
- Then, attach ends to the mini-greenhouse. Use special clips or make your own from plastic tubing.
- Finally, put the plastic over the greenhouse. It helps to have two people for this part of the process. Lay two of the 2-by-2-by-10 pieces of wood. Cut a piece of plastic, 10 by 10. Lay one edge of the plastic along the wood. Lay the second piece of wood on top. Holding the plastic tightly, screw the two pieces of wood together every 12 to 18 inches. Repeat for the other side.
- Put foam pipe insulation over the end greenhouse hoops to protect the plastic. Place the plastic over the hoops. The weight of the wood will hold the plastic on the hoops. You can roll the plastic up on the hoops to vent the greenhouse on warm days.
- If you are placing the frame over grass, there is no need to dig up the grass. Simply place an inch or so of compost or manure over the grass, cover with cardboard, and fill the frame with soil or compost.
- If you have the space, you can use a similar process to build a greenhouse you can stand up in. You can also buy kits that have all the parts included. Costs can be as low as a dollar per square foot for materials.

Off-Season Plants

- The idea with these greenhouses is to work with nature, selecting plants that are cold hardy and adapted to growing in the off-season. Because there is no heat source, at night it will be almost as cold

inside the greenhouse as it is outside. Plants for the winter garden need to be able to withstand freezing.

- Day length is another important factor. Time your plantings so that the plants are at the right maturity before day length drops below 10 hours per day and growth slows. You are extending the harvest season more than extending the growing season.
- Winter gardening is a solar-driven process: When the Sun comes out, the temperature in the structure will quickly rise to 70 degrees or more, even on a zero-degree day. The plants that freeze at night will recover in the warmth of the structure the next day and can be harvested. You can only harvest when the plants have thawed.
- There are a few exceptions to the “harvest only when thawed” rule. Both mâche and tatsoi can be harvested when frozen solid and look perfectly normal after they thaw—so can scallions and leeks, as



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Mâche is grown for its leaves, which are used in salads.

well as sweet baby carrots, which are hiding in the soil. Spinach and parsley will also recover adequately from being harvested frozen.

- Most plants are somewhat cold hardy when they are small, so baby lettuces are a good choice. Plants with large fleshy stems, such as mature chard, will deteriorate quickly with the freeze-thaw cycles of winter gardening. But baby chard works well.
- Some plants, such as mâche (also known as corn salad), are well suited to winter growing because they are winter annuals and evolved to complete their life cycle in the off-season.
- Mâche, though relatively unknown in the United States, is a common winter salad green in France and Italy. It is very cold hardy and you harvest the whole plant, which is a bit like a miniature head of lettuce. It's one of the best-suited plants for winter gardening. A good variety is Vit.
- Spinach is very cold hardy. You can cut the leaves and they will grow back. A good variety for winter gardening is Space.
- Many Asian greens, such as tatsoi and *pac choy*, are tolerant of cold weather. Tatsoi can be harvested when frozen.
- Endive, chicory, and escarole tend to be a bit bitter, but they are less bitter in a winter harvest garden. They add complexity of flavor to winter salads and are great wilted.
- Starchy vegetables, such as carrots, go through a remarkable transformation in cold weather. The starches get converted to sugars, which act as a kind of antifreeze protection against the cold.
- Growing sprouts is another great way to extend the season. You can do it in an apartment, and some sprouts don't even need light. Sprouting increases the nutritional value of a seed and makes it more digestible.

- There are two basic sprouting methods: in soil or soilless. One of the methods for growing sprouts at home is growing in tray spouts. This method is like mini-farming. You use a small amount of soil in a shallow tray. Good candidates include sunflowers and buckwheat.
- Microgreens are baby versions of vegetables that are usually eaten at larger stages of maturity. The method is similar to tray sprouts. Seed can be expensive. Varieties suitable for growing as microgreens include lettuces and broccoli.
- Finally, you can grow spouts in a jar. Home-scale sprouting systems are readily available.

Suggested Reading

Coleman, *Four-Season Harvest*.

———, *The Winter-Harvest Manual*.

Jabbour, *The Year-Round Vegetable Gardener*.

Questions to Consider

1. What is the minimum protection needed for off-season growing in your area?
2. Find a farmer or gardener in your community who is doing winter production and visit him or her.

Sustainable Water Use

Lecture 7

Sourcing clean water and using water wisely are key elements of sustainable living. In this lecture, you will learn how you can look to nature for inspiration in the design of systems that provide water for drinking, washing, irrigation, and other human uses. You also will learn about smart ways to get the same or better services from less water, and then you will discover sustainable ways to supply this lower demand. By developing a sustainable relationship with water, you will be ensuring supplies of clean water for future generations and for nature.

The Hydrologic Cycle

- The hydrologic cycle is powered by a daily input of solar energy and uses hundreds of times the energy flow that the human economy uses. It has entropic elements, where water is distributed across the globe, collects various impurities, and loses some of its usefulness. It has antientropic elements, powered by sunlight, where water is collected and impurities are removed. It's a core ecosystem service of the economy of nature.
- Water is a renewable resource, but that doesn't mean that its availability is unlimited. In a given period, precipitation is always limited to a certain amount. The same holds true for the amount of water that recharges groundwater reserves and that flows through a river.
- Rainwater can be used in agricultural production, and water in rivers and aquifers can be used for irrigation, industrial, or domestic purposes. But in the long term, we can't take more water from lakes and groundwater reservoirs than the rate at which they recharge. A river can be emptied.
- We also have to leave water for the rest of nature. Rainwater not used for agricultural production is left to sustain natural vegetation. The

groundwater and surface-water flows not used for human purposes or polluted are available to sustain healthy aquatic ecosystems.

- Domestic water use is only 8.5 percent of total water use, so there is really only so much that you can do at home to directly affect overall water usage. But two of the largest U.S. water uses—power generation (that is, the need of large utility power plants to be cooled by freshwater) and irrigation—can be affected at home by generating or buying green power and by growing your own food or buying it locally.

Embodied Water

- Many products have embodied water, which is the amount of water it takes to produce the product. One tool for making embodied water visible is water footprinting. The water footprint of an individual, community, or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business.
- On average, it takes about 1,850 gallons of water to produce 1 pound of beef. Producing 1 pound of soy burger takes only 295 gallons of water. In general, vegetable sources of protein take much less water than animal sources like beef.
- Energy has embodied water, but water also has embodied energy. Energy and water are inextricably linked. Because water is heavy and must move through many process steps before it reaches your tap, public water supply and treatment is energy intensive. Water needs to be pumped from the source to the treatment facility, where energy is used to treat the water. More energy is used to pump the water from the treatment facility to the customer.
- The energy intensity of water ranges from 0.25 to 3.5 kilowatt-hours per 1,000 gallons. Even small community water systems can process billions of gallons of water per year, and this means a lot of energy.

- Energy is typically the largest cost for public water supply companies. Once in customers' homes, there is more energy used in order to heat water for showers, washing, and cooking. Finally, we use energy to treat and discharge wastewater.
- In many places, nature provides water for free; the cost of water is related to pumping, purifying, and distributing it. So, if you collect and use rainwater, you bypass that.

Water in Households

- In a typical U.S. household, water use per person is 80 to 100 gallons per day; 70 percent is used indoors while 30 percent is used outdoors.
- There are four major considerations for sustainable water use in a typical household: using water efficiently, sourcing water, treating polluted waters, and managing storm water.
- Using water efficiently saves water and energy. There is a wide variety of technologies that allow you to get the same or better service with less water, such as low-flow showerheads and water-conserving toilets. Horizontal-axis washing machines (typically side-loading ones) use half the energy and one-third less water than a typical vertical-axis machine and get your clothes cleaner.
- Roughly 27 percent of water used in households is used to flush the toilet, the largest single use. Composting toilets offer an alternative that uses little or no water and recycles waste into a resource: fertilizer for plants. For this reason, composting toilets have many advocates in the sustainability community. Some local governments allow approved composting toilets to be used in place of conventional septic systems.
- In the summer, one of the largest household water uses is watering gardens. The best technology for reducing water use in the garden is drip irrigation, which saves 60 percent of the water used by conventional systems and keeps plants happier. Drip systems

are inexpensive and can be equipped with timers that automate garden watering.

- Pinpointing the water right to plants ensures that the water is not wasted or used to promote weed growth between plants or on paths. A sprinkler, on the other hand, indiscriminately spreads water everywhere.
- Drip irrigation works well with low-pressure and gravity-fed systems, because water drips slowly from the emitters. Drip irrigation keeps a good mix of air and water in the pores of the soil, where overhead watering tends to saturate the soil with water and, when the water drains away, leaves a deficit until the next watering cycle. Plants like drip irrigation.

Supplying Water

- Water is critical for life. It's good design to have multiple sources of water to supply this critical need. This is another example of a principle of ecological design. Each major function (in this case water supply) should be served by several elements (in this case sources of water).
- The major sources of water for household use, in order of sustainability, are rainwater, groundwater, and water from municipal water supplies.
- Harvesting rainwater connects you to the flow of abundance and scarcity in the natural environment around you. Rainwater can be stored in tanks, ponds, and in the landscape. You can set up an inexpensive rain barrel, and with good design and a bit of luck, you can use gravity to distribute the water.
- Groundwater is typically accessed with a well. Groundwater comes from a variety of sources that are replenished at different rates. If we mine water from the ground at rates faster than it is replenished, eventually the resource will be used up. This is happening with

aquifers all over the world. We're using fossil water that in some cases was deposited thousands of years ago.

- Finally, there is water from municipal water supplies. Lots of energy, materials, and chemicals are used in municipal water supplies.

Collecting, Storing, Purifying, and Using Rainwater

- We share water with lots of other life-forms, but in most places, there is plenty of rainwater for human needs if we use it wisely. It's not necessary to have the high-quality potable water for most uses. You don't really need to use clean drinking water to flush your toilet, for example. Each person needs only a few gallons of potable—that is, drinkable—water a day.
- There are some things you can do to collect, store, purify, and use rainwater. The higher your rainwater collection area, the better, because you can use gravity to distribute the water you collect rather than pumps. It's another example of the entropy principle: Once water has reached the lowest point in your property, it has lost some of its usefulness—you can no longer use gravity to move it. Gravity works all day, every day, and never fails.
- Roof and garage areas work well and often already have gutters. You can also collect rain off other hard surfaces, such as driveways and roads. Even gravel driveways are quite impervious to water, so factor them in, too, when you're looking for opportunities. It's easier to store rainwater collected off driveways in ponds or in rain gardens.
- You can collect water in the landscape by building shallow ditches on contour. A contour line is a line that runs across a slope at a constant elevation. Ditches on contour are called swales and hold water in the landscape rather than letting it run off. Plant the downhill side of the swale and your plants will be automatically watered by the water that infiltrates through the swale.

- Ditches with a slight slope (called diversion drains) can lead water to storage areas (ponds and wetlands, for example). You may be able to use existing ditches to collect water.
- Rainwater can be stored in barrels. You can buy a rain barrel, or you can make one from a surplus 55-gallon plastic barrel. Barrels can be connected to get larger amounts of storage. If your barrel is higher than your garden, you can use gravity to deliver the water. Even a few feet above your garden is enough to run most drip irrigation on gravity. Keep the barrel screened against mosquitoes.
- A 55-gallon rain barrel connected to roof gutters will quickly fill and overflow even on a small house. These barrels are good for learning about rain catchment, but to reliably supply household and garden needs, you will need larger tanks.
- Reasonably priced polypropylene water storage containers up to 1,500 gallons are available at farm supply stores. Polypropylene is



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Barrels can be used to store rainwater, which can be used to water your garden.

the same material many water bottles are made of. The cost is about 75 cents per gallon.

- Concrete tanks are excellent for storing water and can be buried. Precast tanks of up to 1,500 gallons are commonly used for septic tanks and can be adapted for use as rainwater tanks. Expect to pay about a dollar per gallon of storage.
- Rainwater can also be stored in a pond. For about 500 dollars, you can have a pond dug that will store hundreds of thousands of gallons of water. In a few hours, you can dig a pond by hand that will store thousands of gallons of water.
- For many uses—such as flushing toilets, washing clothes, and bathing—it may not be necessary to do any water treatment. Rainwater used for drinking should be treated, but drinking requires only a few gallons per day per person, from a daily water budget of 50 to 100 gallons per person.
- For drinking, a gravity system with ceramic filters can treat thousands of gallons of water before needing to be replaced. You can also use solar distillation or pasteurization, sand filters, reverse osmosis, and ultraviolet light.
- You'll find that rainwater is great for showering and bathing. Unlike hard well or municipal water in many parts of the country, rainwater is soft. Plants also like rainwater better than water company water, which has chlorine and other biocides added.
- Water often picks up impurities during use that need to be removed before using it again or discharging it in a yard, wetland, or stream. From a thermodynamics point of view, it's useful to match the quality of water with the use—not all uses require potable water. Try to match the source of water with the use and use the water many times before purifying it for use again.

- Use biological purification systems rather than mechanical ones wherever possible. Sometimes called “living machines,” they integrate elements of biology and elements of technology. Biological water systems use solar energy and the intelligence of biology to purify water. Biological systems, unlike mechanical ones, self-organize, using solar energy to create order and structure.
- Sometimes the impurities in water are an advantage; they can be used as food for plants. Gray water is water that doesn’t have human waste in it, such as the water from your sink, shower, or washing machine. It can be used to irrigate your garden.

Suggested Reading

Jenkins, *The Humanure Handbook*.

Judd, *Edible Landscaping with a Permaculture Twist*.

Ludwig, *Create an Oasis with Greywater*.

Lancaster and Marshall, *Rainwater Harvesting for Drylands and Beyond*.

Schmidt and Shaw, *The Blue Thumb Guide to Raingardens*.

University of Wisconsin–Extension, “Rain Gardens.”

Questions to Consider

1. Look up the annual rainfall for your area and look at the pattern of monthly rainfall. How does this make it easy or difficult to do rain catchment in your area?
2. What are some considerations for the design of rainwater systems in an area that has long periods without rainfall, like much of California in the summer?
3. Investigate useful plants that could be planted in a rain garden in your area.

Transportation Alternatives and the Ecocity

Lecture 8

Cities are the biggest things that people make. Redesigning them as ecocities is one of the biggest factors in global sustainability and improving human welfare. In this lecture, you will explore how these settlement patterns affect sustainability—in other words, you will explore ecocity design. Settlement patterns and city design define transportation requirements, and transportation-system decisions in turn define options for city design. A key challenge of sustainability is transforming our cities from the least desirable and ecological places to live into the most desirable.

Ecocity Design

- In the past, cities were designed around the size and velocity of the human, and today's best cities—such as Florence, Italy—still are. Most of today's cities, however, are designed around the size and velocity of the automobile, which has huge consequences for sustainability. By design, housing, shopping, work, education, and recreation are all segregated in separate districts, requiring cars to access them.
- Cars cause a lot of damage, destruction, and death. They pollute; are noisy; take up a lot of space, time, and money; destroy natural beauty, and are a major cause of death for humans and other animals. They have taken natural landscapes and turned them into cement jungles. Yet we still idolize them, and we have designed our cities to prove how much we worship them.
- Instead of designing cities around community and accessibility, cities are designed to permit a car to go anywhere. The more efficient the car, the more justified we can feel for driving more; better cars lead to more driving. But is that really what we want—what we need?

- If we drive, we should drive the best, greenest cars we can, powered by renewable energy sources. And we can't put people in environments that are designed for cars and take away the cars. Improving cars and making better buildings are good things to do, but we shouldn't let that get in the way of the more fundamental work of reimagining and redesigning their context: the city.
- As an alternative to making better cars, we need to design cities from the ground up for people rather than cars. Cities can be designed so that basic human needs—such as food, education, jobs, entertainment, and access to nature—can be accessed without cars. Ecocity theorist and designer Richard Register calls this “access by proximity,” making the necessities and niceties of everyday life accessible by walking or biking.
- Another element of ecocity design is to rethink single-family home design. It's difficult to get the kind of density needed for access by proximity in a car-free environment if everyone has a suburban-style single-family home. In addition, larger multifamily buildings have a more efficient shape than single-family homes, with less heat-losing surface area needed to enclose a given amount of floor space.
- Access by proximity is made easier if ecocities are built up instead of out, in three dimensions rather than two. The metaphor for the city has been the city as a machine. The metaphor for the ecocity is the city as a living organism, powered by solar energy with a metabolism that fits within ecological cycles.
- When human habitats are denser, then there's more land left for nature. Unmediated nature experiences and wilderness can be close to cities, just a few minutes of walking or by bike.
- Typically, cities are designed with consideration for buildings first and for the space between buildings last or not at all. Jan Gehl, Copenhagen-based city designer and author of the books *Life between Buildings* and *Cities for People*, recommends the following

order for thinking about city design: life (design for people and convivial human interaction rather than cars), space (consideration for the use of public spaces), and buildings (consideration for how buildings fit into space and life).

- The following are five principles of ecocity design developed by Richard Register, author of the book *Ecocities* and founder of the nonprofit Ecocity Builders.
 - Build the city as the living system that it is. Put wastes into cycles, integrate food production, power using solar energy, and harvest rainwater. The form is a well-integrated, complex, three-dimensional shape, facilitating access by proximity. The design metaphor is living systems rather than machines.
 - Make the city's function fit with the patterns of evolution. Go beyond sustainability to regeneration of natural systems and the human spirit. Support and express creativity and compassion. Cities can be a powerful force for human cultural evolution.
 - Start with a foundation of land-use planning that supports the ecocity. Land-use patterns should support the healthy anatomy of the whole city. The land-use infrastructure has to be ecologically tuned from the start.
 - Reverse the transportation hierarchy. Transportation choices support or subvert much that is healthy about cities. Plan for pedestrians first, followed in order by bikes, rail, on-road buses (flexible transit), and cars and trucks.
 - Build soils and enhance biodiversity. Compost and cycle organic wastes. We could create millions of new farmers in America with urban and peri-urban farming.
- We're used to urban infrastructure that doesn't work. The existing urban infrastructure makes it difficult to imagine something different. Making complex, urban environments the most attractive

places for people to live rather than the least attractive places is a central challenge for sustainability.

City Infrastructure and Land-Use Decisions

- City design has an impact on the efficacy of green technologies and the parameters of personal choice. City infrastructure and land-use decisions affect ecological impact and ecological footprint in many ways.
- Even though New York City is not an ecocity, David Owen, in his book *Green Metropolis*, argues that New York City is the greenest place to live in America—because it's compact, and most people live in smaller apartments that are energy efficient by virtue of their small size and shared walls.
- Ecocities go beyond compactness to build in sustainability from the start, providing the proper substrate for the application of green technologies and design strategies. Adding ecocity design to a place like New York City is a way to make change on a large scale, complementing the sustainability efforts we make with our personal choices.
- To transition from current urban infrastructures to ecocities, we have to think about new city infrastructure and retrofitting old infrastructure. These are mostly long-term, multigenerational projects.
- There are several problems with making the ecocity vision the rule rather than the exception. First, in America, there is a dearth of inspiring good examples of car-free design. Many of them are in places around the world that few Americans have visited.
- Second, ecocities are inherently large-scale undertakings, mostly beyond what a person can do on his or her own.
- Third, large, complex public infrastructure tasks require the leadership of government, and in the United States, there has been a focus on individual solutions for sustainability, which are important

and necessary but not sufficient in dealing with the biggest thing that people collectively make: cities and their corresponding transportation infrastructure

- A little more than 100 years ago, all cities were car-free. The few cities that still are—such as Florence, Italy—are some of the most popular tourist destinations in the world.
- Efforts at building ecocities will be mostly long-term efforts. In the meantime, we can spark public imagination by building what Richard Register calls “ecocity fractals,” small pieces of ecocities that can serve to help people imagine what entire ecocities would be like.
- Via Verde—which opened in the Bronx, New York, in 2012—is an example of an ecocity fractal. It’s a 100-million-dollar-project with 500 residents, rooftop vegetable gardens and fruit trees, access by proximity, and renewable energy. The building is tall on the north side and steps down as it goes further south. This optimizes the availability of solar energy for the complex.
- Other strategies that some communities have explored to transition from car-centric to people-centric design are placemaking—a process for getting neighbors together to imagine and design a better public space and then creating it—and traffic calming, which involves slowing traffic and giving preference to pedestrians.

Automobile Options

- Despite the drawbacks of car-based city design, in most cities today, we still need to use cars. A revolution in car design is going on. Quality electric cars are available from major manufacturers. As of 2014, electric car range is 80 to 100 miles, adequate for most commutes and around-town driving. Many people find that the acceleration and overall driving experience is superior to gas vehicles.

- Hybrid cars combine a conventional gas or diesel engine with an electric motor/generator and batteries. This combination allows the conventional engine to run at higher efficiency, dramatically increasing miles per gallon. One of the most popular gets 51 city/48 highway miles per gallon. Most manufacturers have hybrid models available.
- The generator and batteries work with the conventional engine to convert energy normally wasted during coasting and braking into electricity, which is stored in a battery until needed by the electric motor. The electric motor is used to assist the engine when accelerating or climbing hills and in low-speed driving conditions where internal combustion engines are least efficient.
- Hybrids automatically shut off the engine when the vehicle comes to a stop and restart it when the accelerator is pressed. This prevents wasted energy from idling. Hybrids typically are lower in weight and have better aerodynamics, which helps fuel economy.



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Charging stations for electric cars are now widely available across the world, including in the United States, Europe, Japan, and China.

- Plug-in hybrids offer the ability to drive on electric power only. You can use the car as an electric car and plug it in to recharge it. Running on electric power from the grid is typically one-quarter the cost of driving using gasoline. If you don't plug it in, you can still use the car in conventional hybrid mode using gasoline. Range as an electric vehicle varies from 11 miles to 38 miles.
- At the cutting edge of vehicle performance is a hybrid that gets 261 miles per gallon from its hybrid diesel/electric drive train.
- Cars sit idle more than 90 percent of the time. This presents us an opportunity to use the battery in an electric car as a way to even out peaks and valleys in electric grid usage and as a way to store surplus renewable energy for times when it's needed by the grid.
- Owners of electric vehicles that are left plugged in when parked could get paid by the utility company for this energy-storage service. This is called the vehicle-to-grid (V2G) concept. There aren't any cars or grids that have this capability yet, but it's an area of active research.
- If electric cars were widespread, the storage capacity of their batteries could be several times the generating capacity of the grid. We could provide ample storage for excess solar and wind energy from a smart grid connected to smart electric cars.

Transportation Alternatives

- Diesel cars can run on fuel made from waste vegetable oil. The product is called biodiesel, and it can be used as a direct replacement for diesel fuel.
- There is controversy about using plants for fuel. Most commercially available biofuels are made from corn and soybeans. The plants need to be grown in a sustainable way, and there is potential that biofuels can drive up the price of food.

- The infrastructure of city roads was built for cars but can be adapted for widespread bike usage. This would require working out some new city infrastructure for utility biking (as opposed to recreational biking), including showers at work, covered bike parking, buses and subways that accommodate bikes, separate traffic signals for bikes, and separate roads for bikes.
- The best bike infrastructure separates cars from bikes. The provision of separate cycling facilities appears to be one of the keys to achieving of high levels of cycling in the Netherlands, Denmark, and Germany.

Suggested Reading

Gehl, *Cities for People*.

Register, *Ecocities*.

Activities

1. In his book *Ecocities*, Richard Register asserts that the better car makes the worse city. Make a list of reasons why better cars can contribute to poor city design.
2. Compare and contrast access by proximity with conventional city design.

Sustainable Products for the Home

Lecture 9

Sustainable living includes being mindful of what you support with your purchasing choices. Each dollar you spend is a vote of support for a product and the company that makes it. Whether you're shopping for groceries, personal-care products, cleaning products, or even home improvement products, many companies are offering greener alternatives to the items that have been available in the past. The goal of this lecture is to help you navigate a greener course through some of the choices you make every week as a consumer.

Green Products

- The United States Environmental Protection Agency defines a green product this way: "Generally, a product may be considered 'greener' if scientific evidence demonstrates that human health or environmental impacts have been significantly reduced in comparison with other products that serve the same purpose."
- This definition reflects the fact that a product is considered green only in comparison to its competition. This implies that "green" is not an end in itself; it's a process where products can continually get greener, as technology and the marketplace allow.
- Some companies look at sustainability as a short-term trend in popular culture. On the other hand, there are companies that recognize that sustainability is more than a fad and look to provide products and run their company in ways that truly embody the principles of sustainability. These companies have long-term strategies for capturing market share that involve radically rethinking how and where the product is manufactured, packaged, and sold.
- When you look at the huge assortment of products on store shelves, it may not feel like your individual purchase could possibly make

a difference in global marketing trends. But you are, in fact, voting with your dollar.

- By choosing to purchase a product that is made in an environmentally friendly and sustainable facility, packaged with a minimum of materials, and made without harmful chemicals, you are contributing to the growth of a marketplace that not only respects the environment but also respects the consumer.
- Despite our best efforts, the vast majority of what we buy and use every day ends up in the landfill. But the road from the mine or the farm to the factory, to the store, to the consumer, and then to the landfill does not need to be a one-way street. We do not necessarily need to be continually extracting our diminishing resources and throwing them in the dump. We can turn the process into a circular path. We can design our goods so that the disposal step is not a trip to the landfill but, rather, the creation of a new resource.
- In their groundbreaking 2002 book *Cradle to Cradle: Remaking the Way We Make Things*, architect William McDonough and chemist Michael Braungart describe a new approach to manufacturing that works to eliminate the concept of waste and put the inputs and outputs of the industrial economy into closed cycles. Their slogan is “waste = food”: What is waste for one process is food for another.
- They propose that we move away from the so-called cradle-to-grave approach of moving resources through the economy and into the landfill. By taking the view of waste as a potential resource, our consumer choices might actually give us the opportunity to leave a regenerative footprint, one that gives back more than it takes. McDonough calls this concept “cradle to cradle”—continually cycling old materials into new products.
- There are health implications of using greener products, too. Our personal environment is made up of manufactured goods. In many cases, these products provide us with a comfortable lifestyle, but they may be endangering our health. The materials and chemicals

in the products that surround us, such as plastics and petroleum products, have been implicated in a wide variety of ailments.

- Air pollution from burning fossil fuels also has health implications. Increasing our use of greener products reduces our exposure to many of the harmful effects of petroleum products and tailpipe emissions. For example, replacing diesel fuel with biodiesel in school buses would cut their emission of diesel particulates up to 47 percent.

Green Products in Your Home

- Whether you live in a new home, an older house, or an apartment, chances are that the materials are pretty similar. The walls are built with drywall over wood or metal studs, and the exterior is covered with siding of some sort, or a type of masonry like brick or stucco. Inside you have wood flooring, tile, or carpeting, and you have kitchen cabinets, bathroom fixtures, and more.
- There has been a revolution in the availability of green alternatives to conventional building materials, including paints that don't give off toxins and sustainably harvested woods. Some of these products go beyond being less bad to being regenerative.
- One area that has gotten a lot of attention is the carpet industry. Studies show that carpet is replaced on average every seven years, despite the fact that most carpeting, if well cared for, will last up to 25 years. That means that millions and millions of square feet of carpeting are going into the landfill each year.
- The carpet industry is making huge moves toward a more regenerative model. Some companies are producing carpeting out of old plastic soda bottles. This is an illustration of upcycling, which refers to techniques that recycle materials into higher-value products. Not only is this carpeting taking advantage of the energy already embodied in the plastic bottles, but the carpet itself can be recycled again and again as carpet.

- Rather than buy new carpeting, you can save money and reduce waste by simply cleaning your existing carpet. There's a nice selection of natural carpet cleaning products that use plant-based cleaning agents rather than petroleum-based products, and there are carpet-cleaning services that offer nontoxic carpet cleaning.
- When it comes to household cleaning products, perhaps the best way to assure that your cleaners are truly green is to make your own alternatives to commercial cleaning products. White vinegar, which is completely natural and nontoxic, can be used as an all-purpose cleaner.
- For example, a simple recipe consisting of 1 quart of warm water, $\frac{1}{4}$ cup of white vinegar, and $\frac{1}{2}$ teaspoon of liquid soap or detergent will do as well as a glass cleaner as many name-brand products. Some people use old newspapers to wipe the glass, rather than paper towels, which leave lint behind. The vinegar-soaked newspapers can then safely go in the compost.
- Baking soda is great for absorbing refrigerator smells, but it is also a great mild abrasive cleaner for cleaning tile surfaces, tubs, and porcelain sinks. With a little research and experimenting, you can save money and go green by partially or completely eliminating commercial cleaning products.



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Making your own household cleaning products can be cheaper and better for the environment than buying them.

- If you aren't making the products yourself, it can be difficult to determine which of these household materials and products are the "greenest" alternatives. Luckily, there are some certification

agencies that now investigate the claims of manufacturers and make this information available to consumers. Any product can call itself “natural,” but if the product carries the certification of a reputable, independent, third-party certifying agency, chances are much better that you are getting what you are paying for.

- The “certified organic” label on food products indicates that no chemicals were used in raising the ingredients and that the facility it was produced in is also certified organic. There are similar organic certifications for buildings and building materials, appliances, computers, body-care products, and household cleaning supplies.

Reducing Your Ecological Footprint

- There are sustainable ways to reduce our ecological footprint and begin to establish a regenerative footprint that require little research and can be fun and rewarding. Some of these ideas include buying locally, repairing items rather than throwing them away, and buying used items.
- Buying locally does not assure that you are buying a greener product, but at the very least, you are going to help maintain a sense of community. A community business is usually more likely to be concerned about local air and water quality than a business owned by a faraway corporation. Farmers selling at a local market rely on their reputation for raising good, fresh, wholesome food and for caring about his or her own community’s quality of life.
- For that matter, you might consider becoming more involved in making the stuff you need or developing relationships with the people that make the stuff you need. Thousands of people across the country are showing their entrepreneurial spirit by participating in a local value-added economy. They do this in a number of ways, including raising food or making a product using locally grown produce.
- Not all regenerative activities need to be agriculturally based, though. There is a growing movement of self-described “makers” that are using high technology to produce their own customized products, rather than relying on mass-marketed and disposable

consumer items. This might include anything from sewing their own clothes, to using recycled materials, to creating inexpensive electronic microcontrollers to monitor soil moisture and water the garden. Makerspaces are popping up all over the country; they are great places to find a community of like-minded people.

- Repair is once again on the rise. Websites like ifixit.com provide free instructions for repairing a huge range of things, from cars to cell phones. In cities across the United States, repair salons or repair cafés are popping up. These are weekend get-togethers that are designed to allow people to share their skills with others, learn new skills, and get their stuff fixed for cheap.
- Buying used items is easier than ever. Nice consignment shops are now a fixture in every trendy neighborhood, and websites like eBay and Etsy make it easy to find good-quality, gently used stuff. After all, the greenest products are those that we use again and again, rather than buying new.
- Another revolutionary idea that is popping up across communities and neighborhoods all over the United States is sharing. After decades of living an American dream that includes owning your own lawnmower, people are discovering that most of the time, that lawnmower is sitting unused. It just makes sense for neighbors to share certain types of items—not only does it make environmental sense, but it saves money and builds a stronger sense of community.

Economic Implications

- When it comes to things like food, cleaning products, soaps, and body care, organic items cost 20 percent more than the nonorganic equivalents, according to the Organic Consumers Association. But a report published by TechSci Research predicts that United States's organic food market revenues are expected to grow at an average rate of about 14 percent between 2013 and 2018, despite those higher prices.

- Greener products are often more expensive for several reasons. First, the market for organic and green products is smaller, but as demand and supply rise, prices drop. So, if the TechSci report is correct, we should see prices of greener products falling.
- Organic and green products are usually more labor intensive to produce. Chemical shortcuts like harmful herbicides and pesticides cannot be used in the growing or processing of organic products.
- Another reason that organic foods cost more is they receive relatively few subsidies compared to conventional commodity agricultural crops. Processed foods can be artificially cheap, while healthier, fresh fruits and vegetables cost more.
- Why are more and more consumers choosing to pay more despite the higher price tag? In some cases, the products are of better quality and provide better service—and are therefore worth more. In other cases, people are willing to pay more for the health benefits and the satisfaction that comes from being part of creating a more sustainable world.
- Another reason that people are willing to pay a higher price for their food is concern about the animal husbandry practices of large-scale confinement agriculture.
- Many organic food buyers are also concerned with the welfare of workers and want to support local workers and local economics.

Suggested Reading

Bedford and Morhaim, *The Next Industrial Revolution*.

Johnston and Gibson, *Green from the Ground Up*.

Leonard and Conrad, *The Story of Stuff*.

McDonough and Braungart, *Cradle to Cradle*.

———, “The NEXT Industrial Revolution.”

———, *The Upcycle*.

Questions to Consider

1. How could you increase the percentage of your dollars that support sustainable products?
2. Discuss the distinction between conventional recycling and McDonough’s cradle-to-cradle concept.
3. Is purchasing green products about making your ecological footprint smaller or making your footprint regenerative?

Green Economics: Living Well

Lecture 10

In this lecture, you will be introduced to the emerging field of sustainable economics. You will explore why sustainable economics involves more than simply putting a price on social and environmental damage caused by economic activity and letting the market economy work it out. You will learn that the economy is about meeting the individual material needs for a good life and that sustainability means respecting the hierarchy of sustainability: an economy in service to humanity and nature, and humanity functioning in harmony with the laws of nature.

Sustainable Economics

- Economics is about how we get our individual material needs met. Throughout most of history, material comforts were the limiting factors to a good life. It made sense to focus on material economic values as the way to improve human well-being.
- Today, however, for many people, material comforts are no longer the limiting factor in a good life. We lack time for rewarding relationships with other people, pursuing our interests, and giving back to others. We lack a sense of purpose and meaning.
- Sustainable economics recognizes the importance of relationships—and a sense of doing what is right and good—as forces that should drive economic policy, not the other way around.
- Economies are not capable of creating anything of value; they simply facilitate the process of extracting things of value from natural and human resources. Economies are necessary when we go beyond individual self-sufficiency; if we could get all our needs met directly from nature, we wouldn't need an economy.
- Economic sustainability is meeting the economic needs of the present without diminishing the economic opportunities of the

future. Sustainable economics works to ground economics in the real world, including the physical sciences: physics, chemistry, and biology. Sustainable economics says that people must obey nature's laws.

- Unlike abstract concepts like money, real objects like people and cars and trees cannot grow exponentially forever. In nature, things grow, have a period of stable functioning, and then die. Sustainable economics recognizes limits imposed by nature on how much of the resources of the Earth can be dedicated to serving human needs.
- Energy isn't destroyed by use. However, each time energy is used, it becomes less concentrated, less organized, and thus less useful than before. Eventually, all energy becomes unable to produce anything of economic value.
- This lost usefulness is a result of the physical law of entropy. An economy that depends on nonrenewable sources of energy, such as fossil fuels, is not sustainable. As fossil fuels become scarce, their ability to produce things of economic value will diminish and eventually be lost. Even as such an economy continues to grow, the energy needed to meet the needs of future generations is unavoidably diminished and will be depleted.
- Society requires energy, too. People are born as helpless babies and need to be educated and socialized to become productive members of an economy. All this takes energy.
- Even thinking and inventing take energy; 20 percent of the energy used by the body is used by the brain.
- There is also a kind of entropy of social energy: Relationships and social structures need to be renewed and refreshed regularly.
- From this perspective, an economy is a system for optimizing the conversion of low-entropy energy and materials to high-entropy energy and materials, extracting usefulness in the process.

- The production and consumption of goods and services inevitably leads to the conversion of low-entropy energy to high-entropy energy. Thus, economies inherently lead to the degradation of materials and energy—in other words, to the production of waste material and energy.
- Anything of use to people is ultimately derived from nature and society. If, in the process of getting our economic needs met, we use up the usefulness of nature and society, there is nowhere else to get anything of economic value.
- To offset this, physics tells us that we need a high-quality source of energy and systems that will use this energy to recycle and renew the usefulness of materials.
- In nature, biology uses sunlight to offset the effects of entropy. We can use nature as a model as we work to develop an economy that regenerates and renews. In this sense, a sustainable economy is all about sustainable energy. The source of sustainable energy on Earth is solar energy in all its forms: solar electric, wind, hydroelectric, biomass, and more.
- The economy should be in service to society and the environment, but currently, it's the other way around. We do things that are good for society or the environment only if they don't negatively affect the economy. From a sustainability standpoint, the order should be as follows: Is it good for the environment? Is it good for society? And, finally, can we afford it?
- The idea that the economy affects the potentials of society suggests that we need to make enough surplus from the economy to cover the economic costs of the noneconomic things we need to do for society and the environment, such as funding the essential functions of government. There are economic costs for ensuring social equity and justice, protecting the environment, and conserving natural resources.

- One of the roles of society is to put constraints on the economy so that society and the environment aren't exploited by the economy. Sustainable economics is about putting economic value in proper relation to social and environmental value, respecting the hierarchy of sustainability.

Sustainability and Economic Growth

- The mantra of the industrial era is that growth is good. We've created an economy where improvement in the human condition is predicated on continued growth, year after year, in throughput of materials and energy. This kind of growth is called compound growth.
- One of the basic principles of economics is that humans have a preference for the present. The future is inherently uncertain, and if we give up the use of something today, there is a chance that we may not be able to enjoy it in the future. A blunt way to put it is that there is no way to get anything of economic value after you are dead.
- Because economic value is inherently short term, economic incentives alone are inadequate to ensure the long-term investments in nature and society that are absolutely necessary for sustainability.
- There is no economic value to doing things that provide a benefit solely for some future generation. There is no social value in doing so either—you won't know anyone and may not even have any descendants. Doing something for the sole benefit of future generations is an ethical value; we do so because it is the right and good thing to do. Economic values are important for sustainability, but ethical and social values are also necessary.
- According to many, the economic growth rates of the industrial era were an aberration, and such growth rates do not seem to be sustainable in the future. Stocks of fossil energy have allowed a period of compound economic growth, but those stocks are finite. The global economy of the next century must be sustained by the daily inflow of new solar energy. Solar energy available for economic use is large and relatively constant, but it is finite, too.

- The sustainable level of economic wealth on Earth is ultimately limited by the quantity of economic value that can be extracted from the daily inflow of solar energy without degrading the capability of the natural systems of the Earth to provide their essential services, such as assimilating wastes, maintaining the fertility of the land, and purifying water.
- It is the concept of a steady state economy that provides a logical conceptual foundation for the development of a sustainable economy. In nature, an organism that grows forever is a pathology. People are born, go through a period of rapid growth, go through a period of stable functioning, and then die.
- A steady state economy is like a mature forest ecosystem. At any given time, there are areas of the forest that are going through cycles of growth and expansion, areas that are in a period of stable functioning, and areas that are dying. Overall, the flow of energy and material through the forest is constant.
- Like that, a steady state economy will have organizations being formed, organizations going out of business, and organizations in a period of stable functioning, but the overall flow of energy and materials will be constant.
- A steady-state economy is defined as an economy that maintains a constant population, a constant supply of labor, and constant stocks of natural and financial capital. Sustainable energy sources are sequestered from the daily inflow of solar energy, leaving enough solar energy for the other living creatures on the planet. Materials are put into cycles that mimic nature's biological and mineral-cycling systems. The concept of waste is eliminated, and the output of one system becomes the input of another.

Degrowth and Voluntary Simplicity

- The degrowth movement advocates for a planned transition to a sustainable economy rather than one forced by ecological, financial, or social collapse. Degrowth advocates argue that, as a

complement to building a steady state, sustainable economy, we need to “degrow” the negative effects of the growth economy—things like poverty, homelessness, exploitation, pollution, carbon intensity, species loss, and work hours.

- Degrowth aims to maximize happiness and well-being through nonconsumptive means—sharing work, consuming less, while devoting more time to art, music, family, culture, and community. Reimagining and reinventing the “good life” lies at the heart of any transition to a sustainable, low-carbon economy. High-consumption lifestyles simply cannot be adopted by 9 billion people while keeping within the material, energy, and ecological limits of the planet.
- Degrowth advocates argue that an adequate response to these limits requires more than minor changes to current lifestyles. It will require a cultural paradigm shift away from high-consumption lifestyles toward a way of life informed by principles and practices of material sufficiency.
- Research indicates that high-consumptive societies are “mis-consuming”—many people could reduce their consumption while increasing their well-being.
- The world is both starved and stuffed: People are suffering from obesity, and people are starving. Countries suffer from excesses of overconsumption while other countries struggle with meeting basic material needs. There is the possibility for wealthier countries to cut consumption and improve lifestyles, making room for the many in the world that still can benefit from economic growth.

Sustainable Economics and Personal Choices

- Given that we don’t have many policies in place for sustainable economies, what can we do now with our purchasing and investment decisions? We vote in the polling booth at election time, but we vote every day with our purchases and investment decisions. How we spend our private and public money is one way of voting for what kind of world we want to live in.



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A small investment in sustainable living could amount to large savings over time.

- How can we begin to make the transition to a sustainable economy using the collective power of our purchasing and investment decisions? First, respect the hierarchy of sustainability—not always choosing the lowest-priced item without regard to social and ethical factors. Cost is important, but it should be considered in the hierarchy of sustainability.
- There are certifications that can help sort through these kinds of decisions, as well as new forms of business organization that work to expand social and ethical values in business.
- There is movement in the investment industry called socially responsible investing (SRI), which has been around since the 1700s. One segment is mutual funds that are screened for a wide variety of sustainability criteria. For example, there are SRI funds that allow you to invest only in companies that are involved in renewable energy.

- You can gather with your friends in an investment club that helps finance sustainability initiatives in your community.
- You can begin to go from passive consumption to coproduction. One example is home food production. Learn skills that were once common, such as fixing things and making stuff.

Suggested Reading

Collins, *Nature of Investing*.

Daly and Farley, *Ecological Economics*.

Ikerd, *Sustainable Capitalism*.

———, *The Essentials of Economic Sustainability*.

Lovins, Lovins, and Hawken, “A Road Map for Natural Capitalism.”

———, *Natural Capitalism*.

Schor, *Plenitude*.

Tasch, *Inquiries into the Nature of Slow Money*.

Questions to Consider

1. Discuss the distinctions between economic value, social value, and ethical value. Why can't markets deal with purely social or ethical considerations?
2. In a sustainable economy, what is the relationship between society, the economy, and the environment?

Inner Dimensions of Sustainability

Lecture 11

In this lecture, you will explore connectedness from the inside to the outside. You will learn about the inner dimensions of sustainability, including sustainability and spirituality, sustainability and holistic health, and the move away from an industrial-era mindset with the Slow Movement. In addition to the theoretical and practical aspects of connectedness, there is an experiential element. Humans can directly experience the essential oneness of nature through spirituality as well as observation in nature. You can even make it part of your daily routine with meditation. Sustainability is about creating a fundamentally better and more satisfying quality of life.

Sustainability and Perennial Philosophy

- Huston Smith, one of the founders of the field of religious studies, postulates that the world's wisdom traditions are linked by what he calls perennial philosophy. Smith suggests that a common element of the world's religions is the understanding that the divergent outer aspects of life emerge from and are connected at a common source, which he and the writer Aldous Huxley called the "Divine Ground." Others call it being, source, or pure consciousness.
- Smith found that another experience common across cultures is the direct experience of this underlying unity at the core of human consciousness—sometimes in the beauty of nature, sometimes during prayer, and sometimes during meditation. The perennialists go a step further and say that connecting with this source is the highest purpose of human life.
- Many of our ecological problems can be seen as a disconnect—a disconnect of people with nature, a disconnect from the larger society, a disconnect from a sense of purpose and meaning. Huxley, Smith, and the other perennialists suggest that the primary cause of all these disconnects is disconnection with our own inner nature—being. Huxley goes on to suggest that humans can heal the outer

disconnects by direct experience of this underlying, inner unity and that this experience results in a fuller and richer life.

- Deep sustainability explicitly recognizes a core unity of nature that is at the heart of the surface diversity of life. Sustainability is the intellectual understanding and practical application of the interconnectedness of humans and nature. The direct experience of this interconnectedness complements the intellectual understanding of it and leads to a more holistic understanding of sustainability.
- How can we reconnect with something deeper than our surface life, the wholeness that underlies the surface? Some people do it through religion, some people do it by the direct experience of nature, and some people do it with formal techniques of meditation.
- Whatever its form, some way of directly experiencing “being” is an essential part of a sustainability worldview. It’s at the heart of creating a sense of purpose and meaning. The perennialists argue that people need this spiritual connection just like they need air, water, and food. The unsustainable world around us is a direct result of a worldview where the experience of being is missing.

Faith-Based Organizations and Sustainability

- There are many flavors of all the world’s major religions. One thing that religious communities have in common is that most are interpreting their own ancient traditions and practices to encourage environmental awareness, sustainability, and the relation of humans to nature.
- Many of the religious and spiritual practices of indigenous people, including modern ones like the Native American Church, are explicitly grounded in an ethic of care of the Earth and sustainability.
- In the United States, the Christian tenant of stewardship is seen in a concern for the environment and sustainability. Many work to educate against excessive consumerism. Churches operate many buildings and vehicles. By implementing energy-efficiency

strategies, they can use the money saved to further their spiritual and environmental missions.

- Christian communities all over the United States are centers for organizing environmental initiatives, including energy efficiency, solar energy installations, and conservation/stewardship initiatives. Interfaith Power & Light works with congregations nationwide on energy efficiency and renewable energy policy initiatives. Many churches are centers for community gardening.
- In Islam, core environmental concepts include a belief that all things in the world are related to each other, that balance in nature must be maintained or restored, and that the fruits of the Earth may be enjoyed but its resources must not be wastefully exploited.
- Judaism has a wide range of green organizations, including the Green Zionist movement. Jews observe an annual “new year” for trees by planting trees and conducting other ecological efforts. They celebrate by eating grapes, figs, pomegranates, dates, olives, and the grains wheat and barley.
- Religion often explicitly refers to the interconnection of things, and the interconnectedness of things is at the heart of sustainability.

A Holistic Approach to Medicine

- The health of the individual and the sustainability of the planet are intimately linked. Many of the same processes that compromise the health of the planet also contribute to an epidemic of diseases like obesity and diabetes.
- Just as sustainability has given us more holistic approaches to how we provision ourselves with food, water, housing, and energy, new approaches to medicine are taking a more holistic look at human health and well-being.
- Some of these approaches, such as Chinese medicine and Ayurveda (from India), are based on traditional medical systems. These

approaches, even though they are called “alternative” in the West, have been in continuous use by large numbers of people for thousands of years. Some approaches, such as chiropractic medicine, are newly developed.

- Conventional medicine has remarkable successes. Deaths from trauma injuries, infectious diseases, childhood mortality, and many other afflictions have all dropped dramatically due to modern medical advances.
- But wealthy countries with extensive modern medical systems have seen an increase in problems that have been stubbornly resistant to treatment, such as heart disease, obesity, and cancer. These diseases are aggravated by the lifestyle demanded by the industrial economy, the widespread use of toxic chemicals, and the foods delivered by industrial agriculture.
- Holistic medicine focuses on preventative practices, using measures like nutrition, diet, and lifestyle for the prevention and treatment of disease. Holistic medicine looks to take maximum advantage of the body’s natural healing responses.
- Ayurveda is a holistic system of health care that starts with analyses of your particular body-mind type and imbalances. Your body-mind type is then used as the basis for recommendations on diet, daily routine, herbal supplements, behavior, and exercise. Ayurveda is the traditional medical system of India and has been in use for thousands of years.
- Aromatherapy uses fragrant natural plant oils for the purpose of altering one’s mood or improving physical and psychological well-being. For example, some people find the scent of lavender relaxing and soothing.
- The deep rest offered by regular practice of meditation helps keep the stresses of everyday life from accumulating. Stretching



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Holistic health involves focusing on both mind and body, which can be accomplished through meditation.

exercises (yoga) and breathing exercises (*pranayama*) are often used in conjunction with meditation.

- There are many approaches to diet and nutrition within the holistic health movement. Some common elements include eating fresh, lightly processed food grown without chemicals. Other holistic approaches include exercise, herbal and nutritional supplements, homeopathy, chiropractic medicine, and massage.

The Slow Movement

- The industrial economy promised fewer working hours for higher wages. But the reality today is that most Americans are working longer hours. Wages for many have stayed stagnant for decades or have gone down.
- It doesn't have to be this way. There are many countries that are opting for a shorter workweek, including France and Germany at

35 hours per week each. These countries have found that worker productivity per hour rises with fewer hours worked.

- The Slow Movement is an approach to sustainable living with the philosophy that sustainability increases the pleasure and sensuality of life. The organized versions of it, including Slow Money and Slow Cities, have come out of the Slow Food movement. The Slow Movement is an organized opposition to the commoditification and industrialization of life. More than just opposition, it also offers a positive alternative.
- An Italian named Carlo Petrini and a group of activists started Slow Food in the 1980s with the initial aim of defending regional traditions, good food, gastronomic pleasure, and a slow pace of life. The movement has evolved to embrace a comprehensive approach to food and life that recognizes the strong connections between plate, planet, people, politics, and culture. Today, Slow Food represents a global movement involving thousands of projects and millions of people in more than 160 countries.
- In the United States, Slow Food is sometimes confused with an elite approach to gastronomy that involves eating only the most expensive and rarest foods, indifferent to where the food comes from or the social and economic conditions of the farmer. However, the Slow Food philosophy of buying fresh and local does not always cost more.
- Carl Honore, in his book *In Praise of Slow*, gives examples showing that most areas of life can be improved by the Slow philosophy. The Slow philosophy is not about doing everything at a snail's pace; it is a cultural revolution against the notion that faster is always better.
- It's about seeking to do everything at the right speed. It's about savoring the hours and minutes rather than just counting them. It's about doing everything as well as possible instead of as quickly as possible. It's about quality over quantity in everything from work to food to parenting.

- Slow Money, founded by Woody Tasch and described in his book by the same name, is a kind of patient green capitalism that looks to connect investors with projects that don't fit into conventional finance. Most projects are related to farms or building capacity in local food economies.
- Securities laws that make it easy to invest in a shopping mall halfway around the world make it almost impossible to invest in smaller local projects. Slow Money is working to change that with local investment clubs and other ways to connect local money with local entrepreneurs and nonprofits needing cash.
- Although it is not often seen in this light, Slow Food, with its emphasis on a better way of life, has the potential to be one of the most powerful sustainability and environmental organizations in the world.

Suggested Reading

Chopra, *Perfect Health*.

———, *Quantum Healing*.

Lynch, *Catching the Big Fish*.

Schor, *Plenitude*.

Thoreau and Cramer, *Walden*.

Questions to Consider

1. What are some nonmaterial aspects of sustainability?
2. Have you ever had an experience where your individuality was experienced as part of a larger whole? What brought on this experience?
3. How is sustainability about connections between things?

Shifting to a Sustainable Worldview

Lecture 12

Becoming more efficient, using solar energy, and using nontoxic materials and processes can save us money and make our lives healthier. We should all embrace efficiency and substitution. But the real opportunities for improvement in the human condition come when we go beyond tweaking the existing paradigm with efficiency and substitution to a shift in worldview that is deep sustainability, regeneration, and renewal. We need to change from a consumptive, throwaway society to a producing and conserving society.

Permaculture

- In this course, we've been exploring the technologies, infrastructure, and institutions that flow from a sustainable worldview. The following list describes the sustainable world.
 - It is powered by renewable energy.
 - It works in harmony with the natural hydrologic cycles.
 - It bases agriculture on ecological principles, including the life in the soil.
 - It organizes humans across the landscape in ecocities and ecovillages.
 - It puts the economy in proper relation to society and nature.
 - It respects decisions that are not purely economic.
 - It relocalizes the basic necessities of life: food, water, shelter, clothing, and livelihoods.

- It puts significant resources into regenerating and renewing the human and natural resources that human well-being and the well-being of nature depend on.
 - It is lived fully rooted in the abundant flows of natural systems for energy, water, soil fertility, and materials.
 - It uses nature as a model and mentor for technology and systems.
 - It puts technology in service to more people working—but working less at more enjoyable and satisfying jobs.
 - It uses collaborative and inclusive governance and decision-making structures.
- Some of the practical things we can do today to create a sustainable world include installing solar panels; making biodiesel from waste vegetable oil; harvesting rainwater; establishing rain gardens; growing food at home for a four-season harvest; becoming part of a Community Supported Agriculture program; voting with our dollars; building with local, natural materials; and reskilling.
 - When we put all of this together in the proper relationship, using permaculture principles derived from nature, we get designs for sustainable living. The permaculture design process creates wholeness from the disparate technologies of sustainability.
 - Permaculture design is a formal method for designing human habitats that have the stability, diversity, and resilience of natural ecosystems. Permaculture seeks to create a permanent culture based on a permanent, sustainable agriculture.
 - Bill Mollison and David Holmgren developed permaculture in the 1970s from their observation of mature ecosystems. Permaculture is an ambitious and largely successful attempt to apply the principles that govern mature ecosystems to the design of human settlements.

It has been used in climate zones all over the world, from temperate to tropical and from wet to dry.

- Permaculture design is functional design. Often the term “design” is used in the context of the aesthetics of an object, building, or landscape. Permaculture complements a concern for aesthetics with useful function in a landscape, building, or city. Permaculture is a practical method of designing with nature.
- Permaculture has a stated ethics, a set of principles, and a body of practice applying the principles. There have been many formulations of principles over the years. Toby Hemenway, author of a book on applying permaculture principles to gardening called *Gaia's Garden*, describes principles that cover three main areas: principles of functional design, principles derived from energy or living systems, and principles related to attitudes.

Principles of Functional Design

- One of the principles of functional design is to use protracted and thoughtful observation rather than prolonged and thoughtless action. Observe the site and its elements in all seasons.
 - An example of this is a mulch-gardening technique that is developed from observation of nature in the garden.
- Another principle of functional design is to use relative location: Place elements in ways that create useful relationships and time-saving connections among all parts. The number of connections among elements—not the number of elements—creates a healthy, diverse ecosystem.
 - You can do this by locating your garden next to the kitchen. The kitchen garden is something you use every day; it's easy to step out for some fresh herbs. Food scraps can be brought to the compost pile when the compost pile is close to the garden, which is close to the kitchen.
 - Another example is the principle of access by proximity, which means that everything that you need for your life—work,

shopping, banking, recreation, schools—are located near where you live so that you can meet your needs by walking or biking.

- Another principle is to identify, collect, and hold the useful energy flows moving through the site. By saving and reinvesting resources, we maintain the system and capture still more resources.
 - This is an application of the concept of entropy. We're working with the natural fact of entropy when we collect and store the renewable energy that flows around us.
 - Another example is water use. Instead of using fresh, clean, potable water indiscriminately for every household purpose, we use water quality appropriate to the use, such as using gray water for irrigation. Rain gardens and swales hold and store water in the landscape so that we can get more use from the water before it exits the property.
- Another design principle is to choose and place each element in a system to perform as many functions as possible. Increasing beneficial connections between diverse components creates a stable whole.
 - Stack elements in both space and time. You do this when you plan your garden with plant guilds in mind—assemblies of plants that work synergistically together, each plant performing several functions in the guild. Each function should be supported by multiple elements. Redundancy protects when one or more elements fail. We can see this when we plan for multiple sources and storages for water.
- Another principle of functional design is to make the least change for the greatest effect. Find the “leverage points” in the system and intervene there, where the least work accomplishes the most change.
 - Sheet mulch gardening is an example of this—asking what less you can do in your garden rather than what more you can do.



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Growing your own fruits and vegetables can be fun and relaxing, and eating fresh food from your garden has health and economic benefits.

- Finally, use small-scale, intensive systems. Start at your doorstep with the smallest systems that will do the job and build on your successes, with variations.
 - An application of this is in garden establishment: Start with a four-by-four- or four-by-eight-foot garden, develop skills and confidence, and then move on to larger garden projects.

Principles Derived from Energy or Living Systems

- The edge—the intersection of two environments—is the most diverse place in a system and is where energies and materials accumulate. Optimize the amount of edge.
 - This is illustrated by the diversity of people who gather around a successful “makerspace,” a complex connecting point where diverse people come to share and learn from each other.
- Mature ecosystems are more diverse and productive than young ones, so use design to jump-start succession.
 - We see this at work when planting guilds with fast-growing nitrogen-fixing plants and slower-growing fruit-bearing plants.

The fast-growing nitrogen-fixing plants are used to provide mulch and nitrogen in the early stages of the guild and are often later removed as the second-stage succession plants mature.

- We want to use biological and renewable resources. Renewable resources (usually plants and animals) reproduce and build up over time, store energy, assist yield, and interact with other elements.
 - Planting a border of comfrey to keep out weeds is an example of this.
- And always, whenever possible, we want to recycle energy, nutrients, and materials. Supply local and on-site needs with energy from the system, and reuse this energy as many times as possible.
 - Using water as many times as possible as it flows through your system is an example of this. Use washing-machine water to irrigate plants. Solar panels on your roof provide energy.

Principles Related to Attitudes

- Sometimes our attitudes about sustainable living precede our actions and choices, but sometimes they follow from actions we take and results we see. One of these attitudes is to turn problems into solutions. Constraints can inspire creative design.
 - In opposition to what we probably believe, weeds become food, sources of compost, and indicators of nutrient deficiencies.
- Another attitude is to get a yield. Design for both immediate and long-term returns from your efforts.
- An additional attitude is that design limits yield. The designer's imagination limits total yield more often than the laws of physics do.
 - In other words, with strategies like guilds and plant stacking, you can always fit in another plant. Go for it!
- And remember that mistakes are tools for learning. Evaluate your trials. Making mistakes is a sign that you are trying to do things better.

Permaculture Ethics

- All design has implied ethics. In permaculture, the ethics of the design system are stated explicitly. Permaculture ethics are not eco-centric or people-centric—they are co-centric, looking at people in the context of their relationship to the Earth.
- There are three ethics.
 - Care of the people: Design should meet the needs of people. For example, in designing with economic systems, put economics in service to people rather than the other way around.
 - Care of the Earth: Design should enhance rather than diminish the capacity of the Earth's systems and should consider the needs of all the creatures of the Earth.
 - Share the surplus: Once your systems are set up to meet your needs and you have enough, share the surplus with others. Surplus may be time, knowledge, plant material, or any other surplus from your systems.
- Indigenous people like the Tlingit and Haida in the Pacific Northwest have used similar principles to live in the same place for thousands, sometimes tens of thousands, of years. In contrast, in just 200 years, North American settlers have reinvented agriculture along industrial lines and, in the process, have diminished much of the productivity of the rich soils that they found here.
- Modern ecological design systems like permaculture borrow heavily from traditional wisdom about how to live in a place. Traditional wisdom is complemented with knowledge from modern scientific understandings about nature and the world. It's not an attempt to go back to something from the past; it's an attempt to create something based on a new holistic understanding of science and traditional wisdom that has never existed before.
- With this combination of ancient wisdom, modern science, and a holistic worldview based on integrating the two, there's the

possibility that the human footprint on Earth could be positive. Ecological footprinting tracks the impact of sourcing our materials and sinking our wastes, and it helps guide efforts to equitably keep that impact within the regenerative capabilities of the Earth.

- But what if all the by-products of human activity were wetlands, wildlands, and beauty? What if human activity acted in greater concert with the greater ecology of the planet? Then, the human presence on the Earth could be seen as a positive thing.
- Often, we're led to believe that the solutions all lie within individual initiative. And there is much that can be accomplished through individual initiative. But some of the things we need to do, such as ecocity design, are beyond our abilities as individuals.
- The effort of rethinking the world and our place in it in terms of sustainability is going to engage everyone on the planet over the next 50 to 100 years. The changes we need to make are, for the most part, changes that make our day-to-day lives richer. It's a better way to live. It's not a sacrifice to live with an ethic of care of the Earth and care of the people; it gives our lives a greater sense of purpose and meaning.
- In large part, we know what to do to power human society with renewable energy, to feed human society using organic agriculture, and to house people in sustainable buildings. While technology can improve, these technologies are good enough, cheap enough, and available at the household scale, making it practical to adopt them in your life today.
- We've known how to do these things, in most cases, for a long time. Adoption of these technologies has been waiting for a shift in worldview, a shift in collective consciousness that would put them in service to a better world for all humanity. This world will likely be as different from the world we have today as the world of the hunter-gatherer or preindustrial agriculturist is from our world.

Suggested Reading

Berry, *The Great Work*.

Gilding, *The Great Disruption*.

Questions to Consider

1. Does sustainability need to be a big, revolutionary change, or could we get by with minor corrections to business as usual? Why, or why not?
2. In what ways would the sustainability revolution make your life better? In what ways would you be worse off?

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